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ORIGINAL STUDY

Low handgrip strength is associated with a higher incidence of pressure ulcers in hip fractured patients

Enrique Diaz De Leon Gonzalez, Luis Leonardo Leyva Mendivil, Deborah Patricia Salinas Garza, Hugo Gutierrez Hermosillo, Juan Humberto Medina Chavez, Rebeca Palacios Corona

From the Internal Medicine Department, Unidad Médica de Alta Especialidad Hospital de Traumatología y Ortopedia No. 21, Instituto Mexicano del Seguro Social, Monterrey, Nuevo León, México

Pressure ulcers (PUs) are highly frequent in hip fractured elderly patients. This issue has a direct impact in quality of life, mortality as well as healthcare costs. Handgrip strength (HGS) is an efficient, low-cost and straightfoward method to measure functional capacity, as well as the global muscle strength of elderly patients. In this research we are aiming to analyze if low HGS is associated with higher incidence of pressure ulcers within a population of elderly patients with hip fracture from a tertiary hospital from Monterrey, Mexico.

This research, designed as an observational-longitudinal cohort, included 462 patients admitted at the Hip and Pelvic Surgery Department of the Hospital of Traumatology and Orthopedics No. 21, of the Mexican Institute of the Social Security (IMSS), in Monterrey, Mexico. HGS measurement was performed by a trained physician, using a Jamar® Hydraulic Hand DynamometerPatients were grouped into tertiles according to their grip strength measurement and sex. Every patient was evaluated for presence or absence of PUs during hospital admission and followed until discharge.

The general incidence of PUs was 25.7%. The incidence was higher in the weaker subjects (Tertile one 33%, Tertile two 30%, and Tertile three 15%, P=0.001). Pre-fracture Barthel's index, and Mini Nutritional Assessment Scores were lower among participants with PUs. After multivariate analysis, only HGS remained associated with PUs incidence.

Low handgrip strength is associated with a higher incidence of pressure ulcers.

Keywords : orthopaedic surgery ; complications ; pressure ulcers ; hip fracture.

INTRODUCTION

Hip fracture in elderly patients is a serious and disabling condition *(25)*. It is considered a public health problem, which has duplicated its incidence

■ Enrique Diaz De Leon Gonzalez.
■ Luis Leonardo Leyva Mendivil[2].
■ Deborah Patricia Salinas Garza[2].
■ Hugo Gutierrez Hermosillo[3].
■ Juan Humberto Medina Chavez[4].
■ Rebeca Palacios Corona[3].

[1]*Internal Medicine Department, Unidad Médica de Alta Especialidad Hospital de Traumatología y Ortopedia No. 21, Instituto Mexicano del Seguro Social, Monterrey, Nuevo León, México.*

[2]*Unidad Médica de Alta Especialidad No. 21, Instituto Mexicano del Seguro Social, Monterrey, Nuevo León, México.*

[3]*Centro Médico Nacional del Bajío No. 1, Instituto Mexicano del Seguro Social y Hospital Aranda de la Parra, León Guanajuato, México.*

[4]*División de Excelencia Clínica, Instituto Mexicano del Seguro Social, México, Distrito Federal.*

Correspondence : Enrique Diaz De Leon Gonzalez, Internal Medicine Department, Unidad Médica de Alta Especialidad Hospital de Traumatología y Ortopedia No. 21, Instituto Mexicano del Seguro Social, Monterrey, Nuevo León, México

E-mail : edleon20@hotmail.com

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in the last 20 years *(20)*. The number of cases expected for the year 2025, is 2.6 millions *(3,20)*, with an estimated increase to 6.26 million for the year 2050 worldwide *(19,29)*. It is also considered to have a high socio-economic burden in Latin-American countries *(35)*, including Mexico, where is expected to be increased drastically in the following decades, from 29,732 cases reported in 2005 to 155,874 cases in 2050 *(24)*. Therefore, hip fracture represents a global health problem *(7)*, that affects functionally, and economically the elderly population *(19)*.

The elderly patient with a hip fracture diagnosis has higher risk to "all cause" mortality *(1,5)*. Also, most of the individuals surviving this condition will lose their capability to live independently, and about 30% will need assistance to walk up to one year after the fracture *(4,41)*. Hip fracture not only affects functionally, but also economically the patient, his family and the health systems *(29,43)*, since direct costs in the UK for hip fracture were calculated between £ 5563 to £ 20000 million (8,951.7 to 32,183 million US dollars) in the 1990's, compared to $ 13.8 billion in the USA *(19)*. In Mexico, direct costs for osteoporotic hip fractures were calculated in US$ 106,529,000 in the year 2000, making a real economic burden, since Mean Gross National Income ranges between $ 410 to $ 7550 in Latin American countries *(35)*. However, this cost might increase if the patient develops other complications.

Hip fractures in elderly people are associated with many complications such as deep venous thrombosis, and pulmonary embolism *(33)*, cerebro-vascular disease, and pressure ulcers (PUs) *(23)*, among others. PUs are a highly frequent complication *(23)*, with a reported incidence from 8.8% to 55%, despite preventive measures *(2,20)*, having great impact on cost of hospital care, quality of life and mortality *(20,30)*. Muscle strength has proven to be an independent predictor of functional outcome *(3,11,32,41)*, and mortality in hip fractured elderly patients *(34)*. Therefore, handgrip strength (HGS) is an efficient and straightfoward method of global muscle strength *(8)*, as it can be correlated to leg strength and clinical outcomes *(27)*, and is also reported to be a reliable predictor for PUs development *(20)*. There is only one study that associates HGS and PUs incidence in hip fractured patients *(20)*, which motivated the group to carry out the present project, with the objective of determining if low HGS is associated with higher incidence of pressure ulcers, in a population of elderly patients with hip fracture from a tertiary hospital from Monterrey, Mexico.

PATIENTS AND METHODS

The present longitudinal study was carried out in the Hip and Pelvic Surgery Department of the Hospital of Trauma and Orthopedics No. 21, a tertiary hospital, from the IMSS, in Monterrey, Mexico. The hospital gives medical service to the northeast federal states of Mexico. The study included patients older than 69 years, admitted for hip, acetabular or pelvic ring fracture surgery from 1st of February 2013 to 31st of March 2014, who accepted to participate in the study and signed informed consent. Individuals who had pressure ulcers before admission and pathological fractures were excluded from the study. The study was evaluated and approved by the local Ethics and Research Committee (Reg. Number R-2014-1903-8).

Socio-demographical data, such as age, gender, marital status, and scholarly were taken from a structured interview with the patient and their relatives or caregiver, during the first 48 hours from it´s hospital admission. Furthermore, medical history of diabetes, hypertension, current diagnosis of cancer, pulmonary disease, heart and coronary disease, hypothyroidism, rheumatism, stroke, chronic renal failure, depression, dementia, Parkinson´s disease, delirium, history of previous hospitalizations, falls in the last year and diaper use, were also included as dichotomous variables. Additionally, quality of vision and hearing were evaluated through self-report, where the patient ranked then in a five-part scale between excellent and very bad.

Handgrip strength measurement was performed by the same trained physician, using a Jamar® Hydraulic Hand Dynamometer. The test was executed with the patient´s elbow at 90° of flexion and encouraging patient´s maximum force. Three

measurements were taken for each hand, allowing a minute rest between tests to ensure muscular recovery. The average result of each hand was recorded for analysis. The dominant hand was identified and registered to indentify strength changes due to dominancy. Patients were grouped into tertiles according to their grip strength of the non-dominant hand, as employed by Gumieiro *et al. (20)*.

Among the clinimetric variables, the pre-fracture functional capacity was assessed using Barthel Index Score *(31)*. All patients were evaluated for mental, nutritional status, and comorbid conditions through the Mini Mental State Examination test *(13)*, the Mini Nutritional Assessment scale (MNA) *(9)*, and the Charlson Co-morbidity Index, respectively.

Every patient was evaluated for the development of PUs during hospital admission and followed up until discharge. Pressure ulcers were identified as "localized area of damaged skin and under laying tissue over a bony prominence", in any of the four stages, as defined by the European Pressure Ulcer Advisory Panel *(10,20)*.

All statistical analyses were performed using Stata/SE, version 12 (Stata Corporation, College Station, TX, USA). Descriptive statistics were used to characterize all subjects. For numeric variables, mean and standard deviation was applied. For qualitative variables, frequencies and percentages were used. Fisher or chi-square tests were employed to demonstrate a difference between qualitative variables. Student's T, and ANOVA's tests were used to establish the difference between quantitative variables Multivariate analysis was performed with Logistic Regression and odds ratio was reported. P values lower than 0.05 were considered statistically significant.

RESULTS

Four hundred and sixty two elderly patients (>69 years old) admitted were included and grouped in the different tertiles, adding the weakest subjects to tertile one and the strongest to tertile three (Table 1). Participants with lower handgrip strength were older, had a greater Charlson Co morbidity Index Score, had higher incidence of stroke, depression, dementia, Parkinson's disease, delirium, and had worse vision and hearing quality. As well, they had more need of diaper use, lower scores on pre-fracture Barthel index, lower Mini Mental State Examination scores, and worst nutritional status.

The general incidence of pressure ulcers was 119 (25.7%), and 50 (33%), 44 (30%), and 25(15%), according to tertile one to three, respectively (P=0.001) (see Table 2). Low handgrip strength was found to have higher association with PUs incidence, even after being adjusted for covariates (see Table 3). The results showed no differences between patients with or without pressure ulcers according to socio-demographic characteristics (including sex), vision and hearing quality, and Charlson Co morbidity Index score. However, pre-fracture Barthel´s index, and Mini Nutritional Assessment scores were lower among participants with PUs. After multivariate analysis, only low handgrip strength remained associated with the incidence of PUs (see Table 3).

DISCUSSION

The main objective of the present study was to determine if low handgrip strength is associated with a higher incidence of PUs. We also tried to identify those patient related factors that might affect HGS.

While revising the variables, we found that age, number of comorbidities, functional, mental and nutritional status had a statistically important impact in handgrip strength scores *(41)*. This is comparable to other studies that support these changes as there is an age related muscle mass loss as sarcopenia, and is regulated by nutritional status, chronic diseases and lifestyles among others *(6,8,14,36,37,40)*. Although other studies have established that males have usually higher scores in HGS tests, no significant differences in HGS were found between males and females *(6,37)*.

No significant differences were found in strength related to scholarly. However, laboring history was not evaluated in this study, there are reports that prove its relevance. Moy, *et al (36,37)*, reported a strong relationship between HGS and occupational history, as patients who had a heavy manual work

Table 1. — Handgrip strength Percentiles by Group

Variables	Tertile 1 n=151	Tertile 2 n=149	Tertile 3 n=162	p
Sociodemographic Characteristics				
Age in years	82.7±7.23	82.28±6.75	79.59±6.52	<0.001
Female sex	108 (71.5%)	110 (73.8%)	112 (69.1%)	0.658
Scholarity (years)	4.23±3.62	4.20±3.83	4.19±3.95	0.997
Charlson Co morbidity Index score	1.96±2.11	1.38±1.87	1.14±1.66	0.001
Co morbid conditions				
Diabetes Mellitus	50 (33.1%)	49 (32.9%)	55 (34.0%)	0.978
Hypertension	82 (54.3%)	85 (57.0%)	95 (58.6%)	0.737
Current Cancer	3 (2.0%)	7 (4.7%)	5 (3.1%)	0.412
Pulmonary Disease	12 (7.9%)	11 (7.4%)	12 (7.4%)	0.978
Heart disease	36 (23.8%)	30 (20.1%)	26 (16.0%)	0.225
Coronary disease	15 (9.9%)	13 (8.7%)	17 (10.5%)	0.867
Hypothyroidism	4 (2.6%)	6 (4.0%)	4 (2.5%)	0.687
Rheumatism	5 (3.3%)	3 (2.0%)	1 (0.6%)	0.226
Stroke	20 (13.2%)	9 (6.0%)	11 (6.8%)	0,049
Chronic Renal Failure	18 (11.9%)	11 (7.4%)	16 (9.9%)	0.414
Depression	32 (21.2%)	30 (20.1%)	17 (10.5%)	0,021
Dementia	87 (57.6%)	41 (27.5%)	17 (10.5%)	0,000
Parkinson	23 (15.2%)	9 (6.0%)	10 (6.2%)	0,006
Delirium	67 (44.4%)	39 (26.2%)	17 (10.5%)	<0.001
Previous Hospitalization	25 (89.3%)	14 (100.0%)	15 (93.8%)	0,707
History of falls in the last year	93 (61.6%)	81 (54.4%)	81 (50.0%)	0.116
Diaper use	47 (31.1%)	29 (19.5%)	11 (6.8%)	0,000
Quality of Vision				0,015
Good	16 (10.59%)	22 (14.76%)	20 (12.34%)	
Bad	82 (54.30%)	97 (65.10%)	109 (67.28%)	
Really bad	53 (35.09%)	30 (20.65%)	33 (20.37%)	
Quality of Hearing				0,027
Good	66 (43.71%)	71 (%)47.65	92 (56.79%)	
Excellent	1 (0.66%)	0 (0%)	0 (0%)	
Bad	40 (26.49%)	52 (34.89%)	47 (29.01%)	
Very good	4 (2.64%)	1 (0.67%)	3 (1.85%)	
Very Bad	40 (26.49%)	25 (16.77%)	20 (12.34%)	
Fracture Type				0,513
Intracapsular	40 (26.49%)	39 (26.17%)	54 (33.33%)	
Extracapsular	102 (67.55%)	102 (68.46%)	98 (60.49%)	
Others	9 (5.96%)	8 (5.63%)	10 (6.17%)	
Clinimetric Variables				
Pre-fracture Barthel Index score	66.85±27.85	82.03±18.03	90.82±11.46	<0.001
Mini Mental State Examination Score	9.85±10.57	19.07±8.97	22.85±7.79	<0.001
Norton Pressure Ulcer Scale Score	8.83±2.15	10.58±2.25	11.85±1.74	<0.001
Mini Nutritional Assessment Score	15.60±5.15	18.29±4.17	20.56±3.79	<0.001

The data represent mean standard deviation, absolute frequencies (%) and were compared with ANOVAs and Squared Chi tests Respectively to obtain p values.

Table 2. — Comparative analysis of variables between participants with and without pressure ulcers.

Variables	With Pressure ulcer n=119	Without Pressure ulcer n=343	P
Sociodemographic Characteristics			
Age in years	81.06±7.28	81.65±6.86	0.425
Female Sex	89 (74.8%)	241 (70.3%)	0.346
Scholarity in years	4.12±4.02	4.24±3.73	0.753
Charlson Co morbidity Index score	1.72±2.14	1.41±1.82	0.118
Co morbid conditions			
Diabetes Mellitus	45 (37.8%)	109 (31.8%)	0.229
Hypertension	71 (59.7%)	191 (55.7%)	0.450
Current Cancer	5 (4.2%)	10 (2.9%)	0.495
Pulmonary Disease	7 (5.9%)	28 (8.2%)	0.418
Heart disease	30 (25.2%)	62 (18.1%)	0.093
Coronary disease	11 (9.2%)	34 (9.9%)	0.832
Hypothyroidism	5 (4.2%)	9 (2.6%)	0.387
Rheumatism	2 (1.7%)	7 (2.0%)	0.807
Stroke	11 (9.2%)	29 (8.5%)	0.792
Chronic Renal Failure	10 (8.4%)	35 (10.2%)	0.568
Depression	20 (16.8%)	59 (17.2%)	0.922
Dementia	44 (37.0%)	101 (29.4%)	0.127
Parkinson	14 (11.8%)	28 (8.2%)	0.239
Delirium	37 (31.1%)	86 (25.1%)	0.201
Previous Hospitalization	19 (90.5%)	35 (94.6%)	0.407
History of falls in the last year	73 (61.3%)	182 (53.1%)	0.117
Diaper use	25 (21.0%)	62 (18.1%)	0.481
Quality of Vision			
Good	15 (12.60%)	43 (12.53%)	0.732
Bad	71 (59.66%)	217 (63.26%)	
Very bad	33 (27.73%)	83 (24.19%)	
Quality of Hearing			
Excellent	0 (0%)	1 (0.29%)	
Very good	1 (0.84%)	7 (2.04%)	
Good	68 (57.14%)	161 (46.94%)	0.319
Bad	33 (27.73%)	106 (30.90%)	
Very Bad	17 (14.29%)	68 (19.83%)	
Grip strength			
Tertile 1	50 (42.0%)	101 (29.4%)	0.001
Tertile 2	44 (37.0%)	105 (30.6%)	
Tertile 3	25 (21.0%)	137 (39.9%)	
Type of Fracture			
Intracapsular	30 (25.21%)	103 (30.03%)	0.147
Extracapsular	83 (69.74%)	219 (63.85%)	
Others	6 (5.04%)	21 (6.12%)	
Clinimetric Variables			
Pre-fracture Barthel Index Score	75.36±25.01	81.81±21.20	0.007
Mini Mental State Examination Score	16.26±10.96	17.79±10.52	0.177
Norton Pressure Ulcer Scale Score	10.07±2.18	10.58±2.45	0.043
Mini Nutritional Assessment Score	17.20±5.03	18.56±4.73	0.008

The data represent mean standard deviation, absolute frequencies (%). and were compared with Student´s T test and Squared Chi Respectively to obtain p value.

Table 3. — Multivariate Analysis for the Incidence of Pressure Ulcers

Variable	P[a]	OR (CI 95%)
Tertile 1 of Grip Strength	0.007	2.490 (1.280-4.842)
Tertile 2 of Grip Strength	0.006	2.263 (1.271-4.029)
Tertile 3 of Grip Strength		1
Age	0.134	0.975 (0.944-1.008)
Male sex	0.284	0.768 (0.461-1.280)
Mini Mental State Examination[b]	0.761	1.004 (0.977-1.033)
Charlson Co morbidity Index[b]	0.500	1.039 (0.929-1.162)
Norton Pressure Ulcer Scale[b]	0.816	1.015 (0.892-1.156)
Mini Nutritional Assessment[b]	0.416	0.975 (0.919-1.036)
Pre fracture Barthel Index[b]	0.438	0.995 (0.983-1.007)

[a] : p was obtained Through Logistic Regression analysis. [b] : Denotes scores in its respective scale. OR : Odds ratio. CI : Confidence interval.

will develop more strength than patients that had light work. This might be important to consider, as our population have different degrees of manual jobs, and muscle training may maintain specific physical capacities despite age related changes *(16)*.

Charlson Co morbidity Index score was found to be statistically different according to grip strength tertiles. Nevertheless, among the comorbidities, only stroke, depression, dementia, Parkinson disease and delirium were statistically significant. Those are known diseases that have a high impact in functional and cognitive capacities, and can explain the frequent need of diaper use, lower pre fracture Barthel Index and Mini Mental State Examination scores, in the lower strength groups ($p<0.001$).

Sensory impairment was found to have a statistical relevance in functional decline. As shown in Table 1, lower scores of vision and hearing quality were found in weaker tertiles ($p=0.015$ and $p=0.027$). This association was also found by Michael Lin MD *(28)*, as he found that the combination of hearing and vision impairment were associated to functional and cognitive decline in older women, in a multivariate analysis. Although history of diabetes may have a direct impact on vision quality, and reports have shown an independent association to grip strength *(14)*, we did not find a direct relationship in our study group.

Hip fracture site is reported to have a close relationship to bone mineral density (BMD) *(18)*. Although there are some studies that relate handgrip strength with BMD *(12,26)*, we found no significant relationship between grip strength and fracture site. Lin *et al.* *(29)*, found that individuals with cervical fractures had better BMD than patients with trochanteric fractures, which also had a higher cumulative mortality in 3 to 5 years. Therefore, an association with muscle strength, MBD and hip fracture site is likely to be assumed ; however more studies are needed to prove this hypothesis.

Although extrinsic and intrinsic risk factors for PUs development have been identified *(2,30,44)*, we focused this study on patient related factors as age, sex, comorbidities, and the effect of mental, physical and nutritional status on grip strength and PUs development. Nevertheless, only HGS showed statistical significance for PUs incidence in the multivariate analysis.

Low nutritional status is a well-known intrinsic factor for PUs development and low HGS, as shown in our results. Although, there are reports that have a limited prognostic value *(20,21)*, we found that Mini Nutritional Assessment score had a relevant relation to HGS changes and PUs development. MNA and Body Mass Index (BMI) are considering being useful tools for PUs prediction in hip fractured patients *(8,22)*. Nevertheless, BMI is limited in the elder patient because of posture alterations, kyphoscoliosis and individual height loss due to ageing *(22)*. Nutritional screening is another valuable tool for predicting and reducing complications in hip fractured patients, including PUs as described by Hommel *et al.* *(22)*, found a reduction of 50% of patients who developed PUs during hospital stay, as they received nutritional supplementation.

According to the results obtained in this study, low HGS was related to a higher incidence of PUs. Based on the study by Gumiero *et al.* *(20)*, we found that the incidence of PUs was mainly associated with functional capacity that can be measurable with the handgrip strength test. This might have a predictive value, as we found that PUs incidence was higher in the lower strength tertile. Furthermore, a direct relationship was found between the measurement of strength and PUs development.

Handgrip strength measurement has proved to be a useful, reliable and low cost tool for screening many traits in the elderly population *(3,6,14,36,37,40,41)*. In addition to its prognostic value of PUs development in hip fractured patients, it has also been reported to have prognostic values for premature mortality and disability *(36)*, indicator of nutritional status and protein defiency *(42)*, functional disability *(27)* and risk of falls in the elder population *(17)*.

The limitations of this study were that the medical conditions of the population studied and its daily activities are considered self-reports of health status. Several studies have found consistency between self-reports and direct measurements *(38,39)*, that were not considered in this study. Sarcopenia and frailty were not considered in this study, this are related to lower HGS scores *(8,15)*, that could have an effect in the obtained results. It might be also considered that ethnic and laboring history may have an important influence on test results, as shown by Forrest *et al. (14)*. Also, HGS measurement is limited to subject's cooperation, body composition and posture of the shoulder, elbow and wrist (16,20). Therefore, these limitations are to be considering for further studies.

The present study has many strengths, including significant sample size of men and women, the prospective design, the ability to evaluate multiple medical conditions and factors previously reported that are associated with PUs development.

Autor contributions

Study Design : DLGE, GHH, MCJH, LMLL and SGDP. Data acquisition : DLGE, GHH, LMLL and SGDP. Data analysis : DLGE and LMLL. Interpretation of data : DLGE, LMLL and SGDP. Drafting of manuscript : DLGE and LMLL. Revision of manuscript : DLGE, GHH, MCJH and LMLL. All the authors approved the final version of the manuscript.

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