Archives of Osteoporosis (2020) 15: 185
https://doi.org/10.1007/s11657-020-00750-3

ORIGINAL ARTICLE

Hand grip strength and early mortality after hip fracture

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Received: 8 January 2020 / Accepted: 4 May 2020 / Published online: 21 November 2020

Abstract

Summary This research describes the risk of death in elderly after hip fracture according to their strength, measured by hand grip. The result is that the weaker the patient, the greater the risk of death after hip fracture, highlighting the need to assess the force in those patients. For the coming years, most of hip fractures will occur in developing countries. It has been described that low muscular strength, measured by grip strength, increases the risk of mortality in those with hip fracture, in both high-and low- income countries. The objective of this study was to determine the mortality among patients with hip fracture and lower hand grip strength (HGS).

Material and methods We conducted a cohort and longitudinal study at Hip and Pelvic Surgery Department of a tertiary hospital, in Monterrey, Mexico. The study included patients aged over of 69, admitted for hip fracture surgery from February 1st 2013 to July 31st 2014. HGS measurement was performed by a trained physician at arrival to emergency department prior to surgery; clinimetric variables were asked, and a complete medical history was included.

Results A total of 670 patients were included in the study and grouped in different tertiles according to hand grip strength. During follow-up, there were 112 deaths (17.4%), 61 (27.5%) in tertile 1, 37 (17.1%) in tertile 2, and 14 (6.8%) in tertile 3, $p < 0.001$. The association remained significant after adjusting for confounding variables. Less than 5% of patients discharged from hospital were identified with osteoporosis.

Conclusion Lower hand grip strength in patients with a hip fracture is associated with high mortality after hip fracture.

Keywords Osteoporosis · Mortality · Elderly · Hip fracture · Hand grip strength

Introduction

Osteoporosis has become one of the most prevalent health problems worldwide in recent years, which has a major negative impact on the general population's health and well-being, and also the economic burden direct and indirect, on the health systems of the different countries that have studied this phenomenon [1, 2].

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As reported by Kanis et al. [1], the prevalence of osteoporotic fractures in the population increases with age. In Latin America, the LAVOS study showed a general prevalence of vertebral fractures of 11.1%, increasing from the sixth decade of life from 6.9 to 27.8% in individuals aged 80 and older [3].

Hip fractures are one of the most feared consequences of osteoporosis. Particularly, the incidence and prevalence of hip fractures are higher in elderly patients. In recent years, the number of hip fractures has increased twice among those aged 80 and older [1, 4], and it is expected to increase in the next decades. By the year 2025, it will be as high as 2.6 million and almost 3 times higher by the year 2050 [5, 6].

Hip fractures have been associated with a great variety of complications, including disability, deep vein thrombosis, pulmonary embolism, pressure ulcers, low quality of life, and mortality, when compared with other type of fractures [4, 7] and this relationship can be extended for long periods after the hip fracture occurred [8], and this relationship can be assessed by measuring HGS.

For the coming years, most of hip fractures will occur in developing countries, but the risk for these fractures has not

been studied in many of them [1]. It has been described that low muscular strength, measured by HGS, increases the risk of mortality in high-, middle-, and low-income countries [9]; this relationship has been proved to be stronger than comorbidity or high medication use [10]. Even though the definitive link has not been fully understood, the close relationship between osteoporosis and muscle weakness has been described for many years and across the world, since they share many common metabolic pathways [11–18]. Worldwide, prevalence of sarcopenia is rising [19–21], and relation with age increases in the prevalence of sarcopenia.

For this reason, we conducted a cohort study in which our general objective was to assess low HGS as a risk factor for early mortality among elderly patients with osteoporotic hip fracture in a tertiary hospital in Mexico.

Material and methods

The present longitudinal study was conducted at Hip and Pelvic Surgery Department of Hospital No. 21, a tertiary hospital, from the Instituto Mexicano del Seguro Social, in Monterrey, Mexico. The hospital provides medical service to the northeast states of México. The study included patients aged over 69 years admitted with hip fracture for surgery from February 1st 2013 to July 31st 2014. The individuals enrolled agreed and signed informed consent to participate in the research. The study was evaluated and approved by the local Ethics and Research Committee.

Variables

Data such as age and gender were obtained from an initial interview with the patients and their caregivers within the 48 h after admission, and before they underwent surgery. Medical history included chronic diseases such as diabetes mellitus, high blood pressure, stroke, cancer, pulmonary diseases, dementia, depression, and Parkinson's disease. The following clinimetric variables were determined: Barthel's Index Score (functional status) [22], Folstein's test [23], Mini Nutritional Assessment scale [24], and the Charlson's Comorbidity Index [25].

Hand grip strength

HGS measurement was performed by trained physician at arrival to the emergency department prior to surgery by using a Jamar® Hydraulic Hand Dynamometer, as described by Gumieiro et al. by using the non-dominant hand [4]. The average result was recorded; the data was clustered in tertiles as described in Savino's work [13], according to the HGS of the non-dominant hand.

Mortality

The participants were followed at the hospital for 1 month after operation, and subsequent every 1 or 2 months for at least 6 months; they were contacted by telephone from February 2014 to July 2015 to determine the survival status, gait, and functional abilities at 1-year follow-up or through review of medical records when telephone contact was not possible to determine whether the patient was still alive or not.

Statistical analysis

Participants were characterized using descriptive statistics, mean, and standard deviation for quantitative variables and as for qualitative variables, absolute frequencies and percentages were applied. Chi-square tests were used to determine differences between qualitative variables, and ANOVA or Student's T test to prove the difference between quantitative variables. p values less than 0.05 were considered statistically significant. The degree of association of variables was measured with hazard ratio through Cox regression model. All statistical analyses were performed using Stata/SE, version 12 (Stata Corporation, College Station, TX, USA).

Results

General characteristics of the patients and grip strength measurements

A total of 670 patients were included in the study and grouped in different tertiles of hand grip strength, being the tertile one for the weakest ones, and the strongest to tertile three (Table 1). Older patients with a lower HGS presented a higher Charlson Comorbidity Index Score, frequency of stroke, depression, dementia, and Parkinson's disease. On the other hand, such patients presented lower scores on pre-fracture Barthel Index, Mini Mental State Examination, Norton Pressure Ulcer Scale, and Mini Nutritional Assessment scales. It is remarkable that according to hospital records, less than 5% of patients prior to discharge were identified as having osteoporosis.

During follow-up, there were 112 deaths (17.4%). Patients who died were older, had lower HGS, more frequency of high blood pressure, lower scores in the Barthel's Index Score, Mini Mental Test Examination, Norton's test, and Mini Nutritional Assessment scales, higher frequency of dementia, and high scores on Charlson's Comorbidity Index (see Table 2). In the multivariate analysis, the low HGS remained a significant predictor of death (see Table 3). Figure 1 shows the Kaplan-Meir mortality curve.

Table 1 Baseline characteristics according to handgrip strength tertiles by group

Variables	Tertile 1 $n = 230$	Tertile 2 $n = 226$	Tertile 3 $n = 214$	p
Age (years)	83 ± 7	82 ± 7	80 ± 6	< 0.001
Gender				
Male	77 (33.5%)	69 (30.5%)	62 (29%)	0.579
Female	153 (66.5%)	157 (69.5%)	152 (71%)	
Comorbidities				
Diabetes mellitus	73 (31.7%)	73 (32.3%)	76 (35.5%)	0.664
High blood pressure	121 (52.6%)	137 (60.6%)	123 (57.5%)	0.22
Cancer	6 (2.6%)	11 (4.9%)	4 (1.9%)	0.168
Chronic obstructive pulmonary disease	18 (7.8%)	16 (7.1%)	16 (7.5%)	0.955
Stroke	27 (11.7%)	15 (6.6%)	9 (4.2%)	0.009
Depression	44 (19.1%)	42 (18.6%)	19 (8.9%)	0.004
Dementia	110 (47.8)	40 (17.7%)	17 (7.9%)	< 0.001
Parkinson's disease	30 (13%)	10 (4.4%)	10 (4.7%)	< 0.001
Clinimetric variables				
Charlson's Comorbidity Index	1.66 ± 1.84	1.17 ± 1.71	0.99 ± 1.56	< 0.001
Pre-fracture Barthel Index Score	68 ± 29	85 ± 17	93 ± 12	< 0.001
Mini Mental State Examination Score	12 ± 11	20 ± 8	23 ± 7	< 0.001
Norton Pressure Ulcer Scale Score	9 ± 3	12 ± 2	13 ± 2	< 0.001
Mini Nutritional Assessment Score	16.4 ± 5.2	20.3 ± 4.6	22.3 ± 3.8	< 0.001

The data represent mean standard deviation and absolute frequencies (%) and were compared with ANOVAs and chi-squared tests respectively to obtain p values

Discussion

The main focus of our study was to determine whether low HGS is associated with high mortality in the year after an osteoporotic hip fracture has occurred, as well as to identify other possible factors related to death. The results clearly show that in the study population, the mortality is much higher in those with low HGS compared with those with better results. These data are similar to those described by Isaia et al. [11], in which the weakest patients had higher mortality at 12 months, and their age was similar, but we report a 3 times larger cohort, which allows to have a stronger association.

The PURE study has shown that a low HGS is a predictor of mortality that shows an increase in it for each 5 kg lost on the follow-up period; moreover, it also has shown that HGS can predict the incidence of other diseases, with some differences across the countries in accordance to their income status. We have previously published that low HGS is related to some complications such as pressure ulcer in individuals with hip fractures [7]. This study was conducted in patients like those described in the middle- and low-income countries that were shown in the PURE study [9].

Other authors have confirmed that a low HGS is associated with mortality. Some have reported a weak recovery even after correcting for confounders in those with hip fracture. It has been described that after 4 years of follow-up, there is an increase in mortality [8]. In our study, we found the same risk during only 12 months of follow-up, which highlights the importance of grip strength measurement in patients with hip fracture due to the osteoporosis.

Savino et al. [12] previously published that among those patients who were able to walk without assistance prior to a hip fracture and the HGS was a predictor of recovery of the walking ability, it showed that the sooner the HGS is measured, the better the predictor will be. In our study, the HGS was measured the day of its arrival to the hospital, hence, minimizing the bias due to loss of strength related to bed rest.

In the Toulouse study of epidemiology of osteoporosis [13], which included 1219 women, muscle mass was measured using dual energy X-ray absorptiometry (DXA) as well as HGS and a knee extension concluding that the predictor is not the muscle mass but muscle force. Even thought we did not measure muscle mass but only muscle force, weak grip strength was related to increased mortality in our weakest group, this was also pronounced in the middle group and there was also an increase in mortality 12 months after the hip fracture; it was not as high, but remained statistically significant.

The vast majority of published papers included mostly women, but it has also been described that measurement of HGS in men is a significant and predictive as it is among women. In this study, one-third of participants were male. The data describe that the strength should be assessed considering that it can be reduced by 10–18% as the patients age [26]. Also, we found that among the 3 groups, the older were

Table 2 Comparative analysis of variables between participants alive or death

Variables	Dead $n = 112$	Alive $n = 532$	p
Age (years)	83 ± 7	81 ± 7	0.002
Gender			0.21
Male	40 (35.7%)	158 (29.7%)	
Female	72 (64.3)	374 (70.3)	
Strength			
Tertile 1 of grip strength	61 (27.5%)	161 (72.5%)	< 0.001
Tertile 2 of grip strength	37 (17.1%)	179 (82.9%)	
Tertile 3 of grip strength	14 (6.8%)	192 (93.2%)	
Comorbidities			
Diabetes mellitus	41 (36.6%)	174 (32.7%)	0.426
High blood pressure	54 (48.2%)	313 (58.8%)	0.039
Cancer	6 (5.4%)	15 (2.8%)	0.169
Chronic obstructive pulmonary disease	13 (11.6%)	35 (6.6%)	0.066
Stroke	10 (8.9%)	40 (7.5%)	0.612
Depression	21 (18.8)	80 (15%)	0.326
Dementia	45 (40.2%)	114 (21.4)	< 0.001
Parkinson's disease	9 (8%)	40 (7.5)	0.851
Clinimetric variables			
Charlson's Comorbidity Index	1.79 ± 2.06	1.19 ± 1.66	0.004
Pre-fracture Barthel Index Score	70 ± 28	84 ± 21	< 0.001
Mini Mental State Examination Score	14 ± 11	19 ± 10	< 0.001
Norton Pressure Ulcer Scale Score	10 ± 3	12 ± 3	< 0.001
Mini Nutritional Assessment Score	17 ± 5.3	20.1 ± 5	< 0.001

The data represent mean standard deviation and absolute frequencies (%) and were compared with Student's T test and chi-squared tests respectively to obtain p values

significantly weaker compared with other two groups; although we did find a decrease in the strength described by Ribom et al. [26], also, we cannot say that the amount of the loss of strength is similar to the one described by Ribom.

Table 3 Multivariate analysis for mortality

Variables	p[a]	HR (CI 95%)
Tertile 3 of grip strength	0.021	1
Tertile 2 of grip strength	0.021	2.107 (1.121–3.959)
Tertile 1 of grip strength	0.006	2.581 (1.315–5.067)
Age	0.022	1.032 (1.005–1.059)
Male sex	0.313	1.23 (0.823–1.839)
Charlson Comorbidity Index[b]	0.031	1.11 (1.01–1.221)
Pre-fracture Barthel Index[b]	0.029	0.983 (0.967–0.998)
Mini Mental State Examination[b]	0.234	0.985 (0.961–1.010)
Norton Pressure Ulcer Scale[b]	0.253	1.059 (0.96–1.168)
Mini Nutritional Assessment[b]	0.071	0.959 (0.917–1.004)

HR hazard ratio, *CI* confidence interval

[a] p was obtained through Cox regression analysis

[b] Scores in its respective scale

Another issue is that low HGS is related to disability and deterioration of the activities of daily life (ADL) [27], the latter also related to mortality in our study, which could mean a bidirectional relationship.

Recent works reviewed other published papers that also reported a strong relationship between HGS and the risk of hip fracture [14]. That is a global concern, but in this study, we

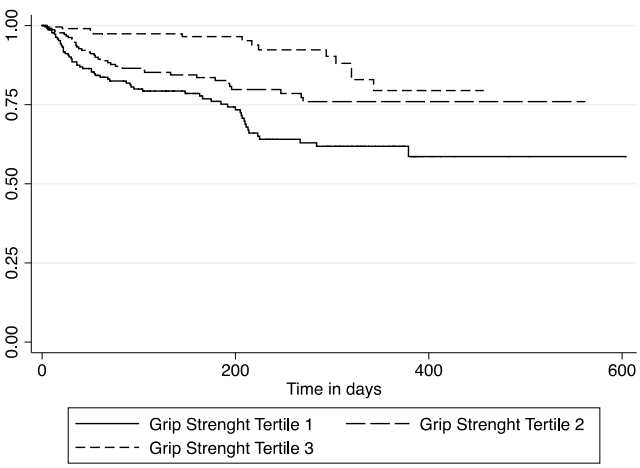

Fig. 1 The Kaplan-Meir mortality curve

aimed to show that HGS is a useful tool to identify patients who had a fracture and are at risk of other complications during next months. HGS measurement has proven in our study that it is a useful, fast, easy, inexpensive, and dependable tool for screening test for weaker patients since the latter is highly related to increased mortality among elderly people; such relationship is concordant with those found by this study and other authors [12, 28–31], although it should be used preferably adjusting the HGS to country-based data [9].

A large number of osteoporotic hip fractures occur in developing countries and this number is expected to increase dramatically in the coming years [1, 2, 32]. Unfortunately, most patients around the world diagnosed with osteoporosis due to hip fracture are not treated with proper medications, calcium, vitamin D, antiresorptive or anabolic; in our study, the percentage of patients receiving treatment after the fracture is similar to which has already been reported in the USA, Germany, or Australia, even though these countries report low percentage of post fracture treatment ranging from 2–7.9% [33, 34]. These data highlight the need to identify patients at high risk of complications after a hip fracture so they can have early interventions to reduce such risk, as stated by others authors [8, 32].

This study has some limitations that include a lack of information regarding to deceased patients, and only patients with social security services were included; also, these data may not represent the general population and we did not have information related to the vitamin D status in each patient.

On the other hand, our study has many strengths including rigorous research methodology, 1-year follow-up after the fracture, and large number of patients from a tertiary hospital where patients from many states of the country are being treated.

Conclusion

In elderly patients with osteoporotic hip fracture, low HGS is a predictor for death 1 year after the fracture. Other factors also related are being older, weak performance in ADL prior to fracture, and having more comorbidities as well.

Compliance with ethical standards

Conflict of interest None.

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