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ORIGINAL INVESTIGATION

Prevalence of sarcopenia and its impact on mortality and readmission rates amongst geriatric patients

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Background & aims. Sarcopenia is a clinical condition characterized by progressive and generalized loss of muscle mass and muscular force, accompanied by an elevated risk of adverse events. The aim of the present work was to evaluate the prevalence of sarcopenia amongst geriatric patients and to analyse its impact on functional impairment, short-term and long-term outcome.
Methods. A longitudinal observational study of geriatric patients hospitalized in the Internal Medicine Ward of the University Hospital of Siena (Italy) was realized. The patients were divided into two groups in relation to the presence of sarcopenia, assessed using the 2010 diagnostic criteria of the *European Working Group on Sarcopenia in Older People.* Association between sarcopenia and functional impairment (evaluated through multidimensional geriatric evaluation) and also impact of sarcopenia on length of stay (LOS), in-hospital mortality, readmissions and mortality at one year from discharge was evaluated.
Results. A total of 119 patients were included (50.4% females), the average age was 82.8 ± 7. The prevalence of sarcopenia was 38.7%. The overall level of autonomy of sarcopenic patients was significantly worse compared to the non-sarcopenic group and the majority of them were more frequently defined as malnourished or at risk of malnutrition (chi-2; $p < 0.001$). The average LOS was 12.8 ± 7.4, significantly longer for sarcopenic patients (15.1 ± 9.7 *vs* 11.4 ± 5; Mann-Whitney; $p < 0.001$). Sarcopenic patients had 3.2 times higher probability to go through readmissions (OR:3.2; $p < 0.05$; CI: 1.19-8.54) and 4.6 times greater probability to die (OR: 4.6; $p < 0.005$; CI 1.74-12.04) during the one year following the hospitalization.
Conclusions. Sarcopenia was associated with cognitive and functional impairment and represented a risk factor for prolonged LOS, readmissions and mortality during one-year after discharge.

Key words: Sarcopenia, Frailty, One-year mortality, Readmissions, Short-term outcome, Functional impairment

INTRODUCTION

The term "Sarcopenia" was first introduced in 1989 by Rosenberg [1] and is defined as a "*clinical syndrome characterized by progressive and generalized loss of muscle mass and muscular force, accompanied by an elevated risk of adverse events as: physical disability, impaired quality of life, and elevated risk of death*" [2]. It is considered the main cause of invalidity and frailty among elderly people [2 3]. Frailty is geriatric syndrome associated with poor clinical outcome, elevated probability of adverse events as accidental falls [4], hospital recoveries, institutionalizations, or death [3].
The aetiology of sarcopenia is multifactorial: it is not always possible to identify causes leading to muscle alteration, it can be classified as *primary* (age-related) and *secondary* (other causes, or unknown origin) [2]. Several studies described the association between the decrease

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of muscle mass with impaired protein turn-over [5] and the age-correlated reduction of anabolic hormones levels [6 7]. Also the "low-grade" state of chronic inflammation (*inflamm-ageing*) [8] plays an important role in the sarcopenia pathogenesis [8-10]. Elevated concentrations of IL-6 and TNF-alpha increase muscle degradation and inhibit proteosynthesis [11] and were associated with the reduction of both hand-grip strength [12] and muscle mass [13-15], impaired functional outcome [16] and higher mortality rates [17].
The diagnostic criteria to identify the presence of the sarcopenia state were established for the first time in 2010 by the *European Working Group on Sarcopenia in Older People* (EWGSOP) [2] and were recently revised [18]. According to the 2010 criteria the diagnosis of sarcopenia requires the assessment of muscle mass, muscle force and function [2], on the other hand, the 2019 revision focus on muscle strength as a key parameter, overtaking the role of the reduced muscle mass, offering also clear cut-off points for variables defining sarcopenia [18]. The recent study confronting both criteria, reported that the prevalence of sarcopenia assessed using the new diagnostic criteria was significantly lower in confrontation to the prevalence based on EWGSOP criteria from 2010, especially for males [19].
The prevalence of sarcopenia is related to age and country of origin, varying from 8.4 [20] to 40.4% [21 22]. The differences reported across the studies are attributable to the different characteristics of the studied population, and also to the use of different diagnostic criteria to assess the presence of sarcopenia [20].
In the population of 60-70 years old the prevalence was estimated to be 5-13%; while in population over 80 years it can reach 11-50% [23]. According to a recent systematic review the prevalence of sarcopenia (defined using EWGSOP consensus) was 1-29% for older adults living in the community, 14-33% for those living in long-term care institutions and 10% for those in acute hospital care [21]. One Belgian study, estimated the prevalence of sarcopenia to be 12.5% amongst community-dwelling people older 80 years [24]. Several studies demonstrated gender difference with a higher prevalence in males [25].
Hospital stay with the following immobilization is considered to be a risk factor for sarcopenia: the GLISTEN study evaluated muscle loss measured by densitometry in the period from admission to discharge; muscle loss was associated with the number of days patients spent lying in bed, but it was not correlated with an overall length of hospital stay [26]. The prevalence of sarcopenia in the elderly (over 65 years) patients in Italy was 34.7% [27].
The aim of this study was to evaluate the prevalence of sarcopenia amongst hospitalized geriatric patients and to analyse its impact on their functional impairment, short-term and long-term clinical outcomes.

MATERIALS AND METHODS

A longitudinal observational study was realized in the University Hospital in Siena (Italy) in the period between February and November 2016. Geriatric patients of Internal Medicine Department (37 beds) were included after the expression of their informed consent.
Patients were divided into two groups (sarcopenic/non-sarcopenic). The presence of sarcopenia was assessed using the diagnostic criteria of EWGSOP consensus from 2010 [2].
1. Muscle mass was assessed through anthropometric measures of mid-arm muscle circumference (MAMC) using the formula: MAMC = mid-arm circumference – (3.14 x thickness of tricipital fold). Measurements were performed with Skinfold calliper FAT-1, on the right side of the patient. A low muscle mass was classified as MAMC < 21.1 in males and < 19.2 cm in females, as in the Sirente Study [28].
2. Muscle force was assessed by measuring handgrip strength (HS) by a digital dynamometer (DynX); HS was measured for both hands, and only the higher value was registered. Muscle strength was considered impaired if HS < 30 kg for males, and HS < 20 kg for females.
3. Physical performance was evaluated using gait speed measurement in 4 metres walking test, assessing a cut-off point for impaired physical performance at the speed < 0.8 m/sec for both sexes.
A multifunctional geriatric evaluation was performed, the evaluated parameters were: level of autonomy: Activities of Daily Living (ADL); Instrumental Activities of Daily Living (IADL); cognitive state: Mini-Mental State Examination (MMSE), affective state: Geriatric Depression Scale (GDS), level of comorbidity: Cumulative Illness Rating Scale (CIRS) and nutritional state: Mini Nutritional Assesment (MNA).
For each patient, the information regarding sex, age, length of hospital stay (LOS), the short-term outcome of hospitalization (discharged/death), destination after discharge (home/nursery institute) were collected.
Patients were followed-up for one year after discharge and data regarding the long-term outcome (death/re-admission) were extracted from the hospital information system.
Primary endpoints were LOS, short-term and long-term mortality and readmission rates during the one-year follow-up.

Statistical analysis

Once the not-normal data distribution was verified (*Shapirò-Wilk*; $p < 0.001$), we proceeded using non-parametric tests (*Mann-Whitney test* to confront the medians between two groups, *Spearman's correlation* to examine an association between continuous

Table I. Reason for hospitalization. Values are reported as %.

	All patients	Males (49.6%)	Females (50.4%)	P-value*	Sarcopenic (39.5%)	Non-sarcopenic (60.5%)	P-value*
RESPIRATORY	34	27	41	0.494	31	38.6	0.935
CARDIOVASCULAR	33	38	29		33	34	
NEUROLOGIC	18	21	16		20	16	
GASTRO-INTEST.	7	9	5		7	7	
INFECTIOUS	3.5	4	3		4	2	
OTHER	4.5	2	5		4	2	

*p-value refers to the chi^2 test

Table II. Patients characteristics (Average age, ADL score, IADL score, CIRS and LOS, number of comorbidities. Confrontation based on the gender and the presence of sarcopenia. Values are reported a Mean values ± Standard Deviation (SD) and Medians (interquartile ranges: IQR).

	All patients		Males (49.6%)		Females (50.4%)		Sarcopenic (39.5%)		Non-sarcopenic (60.5%)	
	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)
Age	82.7 ± 7.0	83 (9)	82.8 ± 7.2	84 (9)	82.8 ± 6.8	83 (9.5)	83.6 ± 7.3	85 (11)	82.3 ± 6.7	83 (9)
ADL	3.65 ± 2.37	4 (5)	4.2 ± 2.3	6 (4)**	3.1 ± 2.4	3 (5)	2.2 ± 2.2	1 (4)	4.6 ± 2.0	6 (4)**
IADL	3.79 ± 3.35	3 (8)	4.4 ± 3.4	6 (8)	3.2 ± 3.3	2 (6)	1.9 ± 2.8	0 (2)	5.0 ± 3.1	6 (6)**
CIRS	2.52 ± 1.24	2 (1)	2.7 ± 1.2	2 (1)	2.3 ± 1.3	2 (1)	2.5 ± 1.1	2 (1)	2.5 ± 1.3	2 (1)
LOS	12.8 ± 7.4	11 (7)	13.5 ± 9.2	10 (9)	12.1 ± 5	11.5 (7)	15.1 ± 9.7	13(10)*	11.4 ± 5	10 (6)
N°comorb.	1.11 ± 0.8	1 (2)	1.2 ± 0.9	1 (2)	1 ± 0.8	1 (1)	1 ± 0.9	1 (2)	1.2 ± 0.8	1 (1)

* Mann-Whitney; *$p < 0.05$ ** $p < 0.001$

variables). The *chi-squared* (chi^2) test was used to evaluate if the distribution of patients within groups was casual. The *Odds ratio* (OR) were calculated in order to evaluate the probability an event will occur.

The potential confounding by age was controlled through a restriction (only geriatric patients > 65 years were included) and through matching (sarcopenic and non-sarcopenic groups had similar characteristics in terms of age, distribution for sex and comorbidities).

Multivariate analysis was performed through logistic regression, in order to identify the variables predicting the outcome, adjusting the association between sarcopenia and outcomes for potential confounders. The significance level was set at 5%. All analysis was realized with Stata 12.

RESULTS

Multidimensional geriatric evaluation: functional, affective, cognitive and nutritional state

In total 119 patients were included in the study, 50.4% were females. The average age was 82.8 ± 7, without any significant difference based on gender or presence of sarcopenia.

The most frequent reason for recovery were respiratory diseases (34.2%), followed by cardiovascular problems (33.3%), on the third place neurologic causes (18%) and finally gastrointestinal (7%) and infectious diseases (3.5%). The most frequent comorbidities were represented by chronic obstructive bronchopulmonary disease (26.7%), stroke (13.8%), heart failure (27.6%) and kidney failure (46.2%). The majority of patients (43%) suffered from one comorbidity; 32% from two or more comorbidities. The average CIRS score was 2.52 ± 1.24, without any difference based on the presence of sarcopenia.

The prevalence of sarcopenia was 39.5% (39% amongst males; 40% amongst females). Any differences in the distribution of comorbidities in relation to gender or presence of sarcopenia were observed. The reason for hospitalization and patients characteristics are reported in Table I and Table II.

Patients were divided into groups based on the scores obtained from multidimensional geriatric evaluation and the presence of sarcopenia. The results are reported in Table III. Sarcopenic patients were more

Table III. Results of multifunctional geriatric evaluation in relation to presence of sarcopenia: cognitive state (Mini-Mental State Examination (MMSE), Activities of Daily Living (ADL), Instrumental Activities of Daily Living (IADL).

Variable	Groups	Sarcopenic	%	NON-Sarcopenic	%	Total	%	P-value
MMSE	> 26	12	26.1	37	51.4	49	41.2	0.000*
	18-24	7	15.2	23	31.9	30	25.2	
	< 18	22	47.8*	9	12.5	31	26.1	
	Nn app,	5	10.9	6	8.3	8	6.7	
ADL	0	13	28.3*	4	5.6	17	14.4	0.000*
	1	11	23.9*	4	5.6	15	12.7	
	2	4	8.7	10	13.9	14	11.9	
	3	4	8.7	1	1.4	5	4.2	
	4	6	13.0	6	8.3	12	10.2	
	5	1	2.2	4	5.6	5	4.2	
	6	7	15.2	43	59.7	50	42.4	
IADL	0	26	56.5*	11	15.3	37	31.4	0.000*
	1	1	2.2	4	5.6	5	4.2	
	2	9	19.6	6	8.3	15	12.7	
	3	0	0.0	4	5.6	4	3.4	
	4	1	2.2	3	4.2	4	3.4	
	5	0	0.0	4	5.6	4	3.4	
	6	4	8.7	7	9.7	11	9.3	
	7	0	0.0	6	8.3	6	5.1	
	8	5	10.9	27	37.5	32	27.1	
GDS	0-9	14	30.4*	39	54.2	53	44.9	0.006*
	10-19	11	23.9	18	25.0	29	24.6	
	20-30	3	6.5	6	8.3	9	7.6	
	Nn app,	18	39.1	9	12.5	27	22.9	
MNA	24-30	5	10.9	29	40.3	34	28.8	0.000*
	17-23.5	17	37.0	32	44.4	49	41.5	
	< 17	24	52.2	11	15.3	35	29.7	

* chi^2; $p < 0.005$

Table IV. Short-term and long-term outcome of hospitalization (in-hospital mortality, type of discharge, mortality at one year after discharge, number of readmissions during one year follow-up). Differences based on the presence of sarcopenia.

		Sarcopenic		Nonsarcopenic		All		P-value
	Groups	N obs	%	N obs	%	N obs	%	
In-hospital mortality	Survived	43	93.5	72	97.3	115	96.6	0.129
	Died	3	6.5	1	2.7	4	3.4	
Type of discharge	Home	36	80	64	89	100	85.5	0.184
	Institution	9	20	8	11	17	14.5	
One-year mortality	Survived	20	52.6	56	83.6	76	72.4	0.001*
	Died	18	47.4	11	16.4	29	27.6	
Number of readmissions	0	7	19.4	30	43.5	37	35.24	0.010*
	1-2	14	38.9	27	39.1	41	39.05	
	> 3	15	41.7	12	17.4	27	25.71	

*chi^2; $p < 0.05$

frequently collocated in the groups with worse results. Regarding the cognitive state, 47% of sarcopenic patients had an overall MMSE score < 18, in confrontation to 12.5% of non-sarcopenic patients. The level of autonomy of sarcopenic patients was significantly worse if compared to the non-sarcopenic: the majority (55%) of sarcopenic patients had ADL score 0-2, while 59% of non-sarcopenic patients reached the maximum ADL score (chi^2; $p < 0.001$). Similar results were observed for IADL: 56.5% of sarcopenic patients had IADL score = 0, while 37.5% of non-sarcopenic had IADL score 8 (chi^2; $p < 0.001$). Average scores for IADL and ADL were significantly lower in sarcopenic patients (IADL: 1.89 ± 2.8 *vs* 5 ± 3.12; ADL: 2.22 ± 2.16 *vs* 4.6 ± 2). Regarding the evaluation of affective state (GDS), sarcopenic patients were more frequently collocated in the group "non-applicable" (39%), having difficulty to perform the test due to their cognitive impairment. The majority of sarcopenic patients were more frequently defined as malnourished (52%), or at risk of malnutrition (37%), while amongst the non-sarcopenic patients only 15% was defined as malnourished (chi^2; $p < 0.000$).

Evaluation of short-term and long-term outcome of discharge

The 85.5% of patients were discharged home, 14% were institutionalized and 3.4% died during the hospitalization; no association with the presence of sarcopenia was observed. Results regarding patient's outcome are reported in Table IV. Average LOS was 12.8 ± 7.4, significantly longer for sarcopenic patients (15.1 ± 9.7 *vs* 11.4 ± 5; Mann-Whitney; $p < 0.001$) and for patients that died during the hospitalization (18.8 ± 5.9 *vs* 12.6 ± 7.4; Mann-Whitney; $p < 0.001$).

The average number of readmissions during the one-year following the hospitalization was 1.6 ± 1.74; 60% of patients went through 1-2 readmissions, 23.5% through 3 readmissions and 16.2% were hospitalized more than 3 times. Sarcopenic patients (OR = 3.2; $p < 0.05$; 95% CI = 1.19-8.54) and institutionalized patients (OR = 6.9; $p < 0.05$; 95% CI: 0.8-59.3) had greater probability to go through readmission during the one year following the hospitalization.

Logistic regression analysis (LR = 11.4; $p < 0.05$) identified the presence of sarcopenia as the only variable able to predict readmission (OR = 2.64; $p < 0.05$; 95% CI: 1.01-6.99).

The mortality rate during the one-year follow-up was 27.6%. Sarcopenic patients had 4.6 times greater probability to die (OR = 4.6; $p < 0.005$; CI 95% 1.74-12.04).

Logistic regression (LR = 44.92; $p < 0.001$) identified age (OR = 1.24; 95% CI: 1.09-1.4; $p < 0.001$) and presence of sarcopenia (OR = 3.6; 95% CI 1.09-11.7; $p < 0.05$) as variables predicting mortality at one year from discharge.

DISCUSSION

The prevalence of sarcopenia reported in our study resulted slightly higher than the results reported by the GLISTEN study, which analysed the prevalence of sarcopenia amongst patients > 65 years (34.7%). Our study showed an association between sarcopenia and altered cognitive state, functional impairment and malnutrition, confirming the important role of this condition in the development of disability, results confirmed by literature [29].

In accordance with previously published studies, we found out that sarcopenia represents a risk factor for a prolonged hospital stay, readmissions and mortality during one-year follow-up after hospitalization [4 30]. These results have a great impact in terms of health-care-associated costs [31].

Moreover, sarcopenia, as an age-related condition, with growing life expectancy will become even more important. These findings are relevant in clinical practice in the management of elderly patients, in order to introduce preventive and therapeutic strategies. Different approaches could be applied: physical exercise is considered the "gold standard" [32-34] as a constant daily physical activity with both resistance and strength-improving exercises may lead to significant improvement of muscle force [35].

Also, an evaluation of the nutritional status is of great importance in global geriatric evaluation, as it helps to identify the elderly with poor nutritional status and to introduce adequate nutritional interventions [36 37].

It has been demonstrated that protein supplementation is able to slow down the loss of muscle mass, especially in combination with physical activity and also to improve the functional outcome [38 39]. A role, that seems to be played by a deficit of Vitamin D, should be further analyzed [40].

The principal limitation of our study was the sample size and the necessity of using the non-parametric tests. The main force of the study is that it did not regard only in-hospital mortality, but evaluated the mortality and readmission rates at one year after hospital discharge, providing information about the real impact of sarcopenia in terms of quality of life.

CONCLUSIONS

Our study showed that sarcopenia is a very common condition among elderly hospitalized patients. We found the association between sarcopenia and poor functional

and nutritional status, and a higher probability of hospital readmissions and mortality at one year from discharge.
Sarcopenia represents a complex issue if we consider the frequent overlapping of loss of function and polypathology in the elderly, it is difficult to understand if sarcopenia is the cause of cognitive and functional impairment, or vice-versa, its consequence [30 41].
Further research is necessary to establish the role of sarcopenia in the loss of self-sufficiency and its repercussion on adverse outcomes in different settings (hospital, nursing homes, private residence).

Conflict of interest

The Authors declare no competing interests.

Ethical approval

Ethical approval was not required as the data were used in a completely anonymous way. The participants expressed their informed consent with being enrolled in the study.

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