Original article

Impact of sarcopenia in SARS-CoV-2 patients during two different epidemic waves

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ARTICLE INFO

SUMMARY

Background: Sarcopenia was reported to be associated with poor clinical outcome, higher incidence of community-acquired pneumonia, increased risk of infections and reduced survival in different clinical settings. The aim of our work is to evaluate the prognostic role of sarcopenia in patients with the 2019 novel coronavirus disease (COVID-19).

Materials and methods: 272 COVID-19 patients admitted to the University Hospital of Modena (Italy) from February 2020 to January 2021 were retrospectively studied. All included patients underwent a chest computed tomography (CT) scan to assess pneumonia during their hospitalization and showed a positive SARS-CoV-2 molecular test. Sarcopenia was defined by skeletal muscle area (SMA) evaluation at the 12th thoracic vertebra (T12). Clinical, laboratory data and adverse clinical outcome (admission to Intensive Care Unit and death) were collected for all patients.

Results: Prevalence of sarcopenia was high (41.5%) but significantly different in each pandemic wave (57.9% vs 21.6% p < 0.0000). At the multivariate analysis, sarcopenia during the first wave (Hazard Ratio 2.29, 95% confidence intervals 1.17 to 4.49 p = 0.0162) was the only independent prognostic factor for adverse clinical outcome. There were no significant differences in comorbidities and COVID19 severity in terms of pulmonary involvement at lung CT comparing during the first and second wave. Mixed pattern with peripheral and central involvement was found to be dominant in both groups.

Conclusion: We highlight the prognostic impact of sarcopenia in COVID-19 patients hospitalized during the first wave. T12 SMA could represent a potential tool to identify sarcopenic patients in particular settings. Further studies are needed to better understand the association between sarcopenia and COVID-19.

1. Background

The 2019 novel coronavirus disease (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), manifests as systemic disorders, particularly severe pneumonia and acute respiratory distress syndrome [1]. COVID-19 is a pandemic that swept around the world. COVID-19 and obesity share metabolic, cardiovascular or pulmonary comorbidities. Obesity has been recognized as a major risk factor for COVID-19-related prognosis, contributing to worse outcomes in those with established COVID-19 [2]. However, other nutritional disorders could affect clinical outcomes in COVID-19.

Sarcopenia, defined as a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength, is observed in some physiological conditions (aging, inactivity) and in several pathologic processes, such as acute and chronic diseases and nutritional deficiencies [3].

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Sarcopenia not only affects respiratory function, motor skill and swallowing profile, but also impairs the immune response [4—7]. In different clinical setting sarcopenia was reported to be associated with poor clinical outcome, higher incidence of community-acquired pneumonia, increased risk of infections and reduced survival in various solid tumors and other diseases [8—13]. Conventionally, measurements of skeletal muscle cross-sectional area and index, at the level of the third lumbar (L3) vertebra, utilizing clinical computed tomography (CT) scans, are considered the gold standard for the assessments of muscle mass [4]. However, when L3 is not available, skeletal muscle area (SMA) evaluation at the 12th thoracic vertebra (T12) level permits the diagnosis of sarcopenia and could be used to correlate sarcopenia with outcome parameters in patients undergoing CT limited to the chest [14,15]. Indeed, a direct relationship between SMA in L3 and T12 level has been recognized [14,15]. Old age and chronic diseases, which were involved in the etiologies of sarcopenia, were identified as risk factors for COVID-19 infection and mortality [16—18]; in addition, sarcopenic patients had compromised respiratory muscle strength and respiratory function, which were detrimental in the treatment of severe pneumonia and acute respiratory distress syndrome [5]. This evidence partially supports the hypothesis of a negative impact of sarcopenia on clinical outcome of patients with COVID-19 [19]. Conversely, COVID-19 could be considered as a risk factor for the onset and progression of sarcopenia because of the reduced physical activity and inadequate protein intake caused by social isolation [20,21].

Researchers have mostly tried to solve the pandemic by studying drugs and developing vaccines; although underappreciated, recognition of and intervention for adverse physical states, particularly sarcopenia, represent novel methods to promote COVID-19 treatment [19].

Recently, the association between sarcopenia and adverse clinical outcomes of COVID-19 has been investigated in some preliminary studies [22,23].

The aim of our retrospective observational study is to investigate the prevalence of sarcopenia and the potential relationship between sarcopenia and clinical outcome in a cohort of hospitalized patients with coronavirus disease.

2. Materials and methods

This retrospective study was approved by the local Ethics Committee (n∘423/2020/OSS/AOUMO) and all alive patients provided written informed consent. Patients with a positive SARS-CoV-2 molecular test, that have been hospitalized in the University Hospital of Modena and have undergone chest Computed Tomography (CT) during hospitalization were included in the study.

Two study groups were identified according to different pandemic periods: the first from February 2020 to August 2020 (first wave) and the second from September 2020 to March 2021 (second wave). Adverse clinical outcomes (admission to intensive care unit, ICU, and death) were recorded in each study group. The following clinical and laboratory data were collected for all patients: age, gender, comorbidities, C-reactive protein (CRP) and albumin level and length of hospital stay.

2.1. Body composition parameter measurements

CT exams were performed at our hospital using a 64-slice CT scanner (Lightspeed VCT, GE Healthcare, Milwaukee, WI, USA). CT examinations were loaded on an Advantage Workstation (VolumeShare 7, GE Healthcare, Milwaukee, WI, USA) and non-contrast images at the level of the 12th dorsal vertebra (D12) were used for reconstructions and measurements of quantitative and qualitative

body composition parameters. According to literature [15], 12th vertebra skeletal muscle cross-sectional areas include erector spinae, latissimus dorsi, external and internal oblique, rectus abdominis and external and internal intercostal muscles. The muscle components were identified using the pre-established Hounsfield Unit (HU) thresholds for muscle (HU -30 to 150) (Fig. 1). The skeletal muscle cross-sectional areas were made manually and the skeletal muscle area (SMA) value was automatically reported. We used specific cut-off values for SMA to define sarcopenic state in accordance with their prognostic role highlighted in two large cohorts [16]: sarcopenia was defined as SMA <92.3 cm^2 in male patients and <56.1 cm^2 in female patients (Fig. 1).

We also measured liver and splenic density using manual ROI (region of interest) on CT scan: according to literature, a difference between liver and splenic density <10 HU is considered statistically significant for steatosis [24].

2.2. Assessment of pneumonia and COVID-19 severity

We analyzed the chest CT scans of COVID-19 patients in relation to type and extent of lung involvement [25]; particularly, we considered:

- Extention: number of pulmonary lobes, a value of "0" is awarded when less than three lobes were pathological, otherwise a value of "1".
- Pattern: ground glass opacities, defined as a circumscribed area of increased pulmonary attenuation with preservation of the bronchial and vascular margins, or consolidations or both (Fig. 2).
- Distribution: central, peripheral (subpleural) or both

2.3. Statistical analysis

Numerical variables were described as the mean and the standard deviation (SD) or as the median and the interquartile range (IQR), whereas categorical variables as the absolute and percentage frequencies. Between groups comparison of numerical variables was assessed with Wilcoxon—Mann—Whitney test, whereas comparison of categorical variables was assessed with the Fisher's exact test. The effect of patient's characteristics on the risk of ICU admission or death (composite outcome) was assessed by using a multivariable Cox regression model. The independent variables that were considered in the model were: wave (2-nd vs 1-st) sarcopenia (yes vs no), steatosis (yes vs no), age (years), gender (male vs female), all relevant comorbidities such as (heart diseases, hypertension, diabetes, dyslipidemia, cerebrovascular diseases, asthma, chronic obstructive pulmonary diseases, chronic kidney disease, cancer, endocrinopathies -yes vs no), sarcopenia × wave interaction and steatosis × wave interaction. The results were expressed as the Hazard Ratio (HR) with 95% confidence intervals. HRs for sarcopenia and steatosis were calculated separately for the 1-st wave and 2-nd wave periods, by using linear combinations of model parameters. Analyses were carried out with R 3.4.3 statistical software (The R Foundation for Statistical Computing, Wien), considering a significance level equal to p-value < 0.05.

3. Results

3.1. Patients characteristics

272 consecutive patients with a confirmed diagnosis of COVID-19 and treated in medical wards of University Hospital of Modena
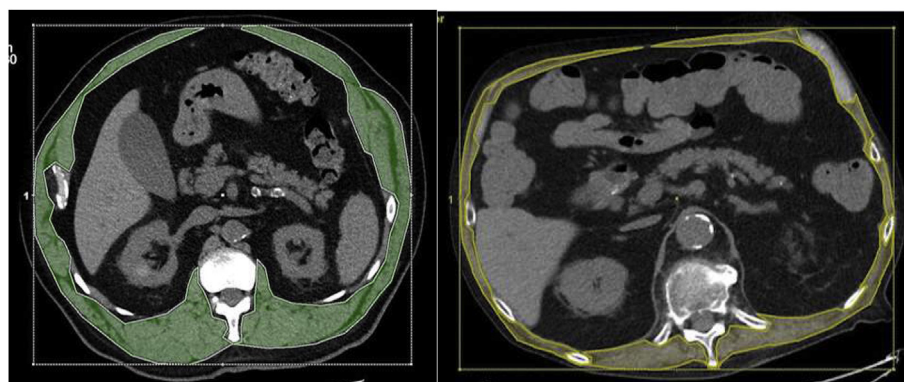
Fig. 1. Muscle mass at the 12th thoracic vertebra. In both images, the area defined in green and yellow represents the muscle component at the level of the 12th thoracic vertebra, manually traced after setting the typical HU interval of the muscle. In A, the SMA values are compatible with a non-sarcopenic patient; in B, the SMA values are characteristic for a sarcopenic patient.
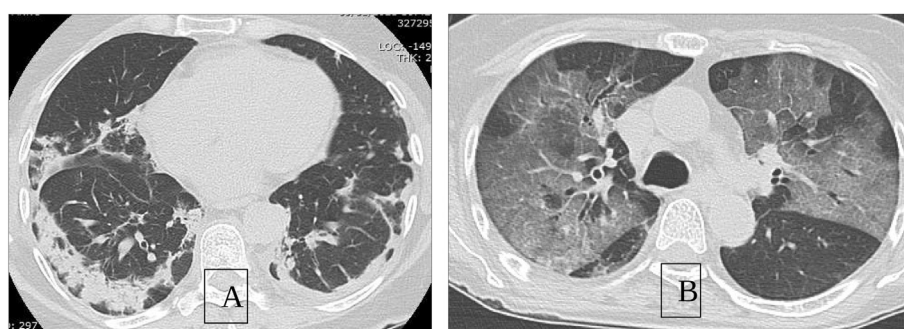

Fig. 2. Radiological pattern of SARS-COV pneumonia. The images show two different pulmonary implications during SARS-CoV pneumonia. A: predominantly consolidative pattern with involvement of the subpleural peripheral parenchyma. B: ground glass pattern with prevalent central distribution.

from February 2020 to January 2021 were retrospectively identified and included in the study. The main characteristics of patients enrolled in the study are summarized in Table 1. The median age was 71 (IQR 61—78) and 62.9% were male. Concerning comorbidities, hypertension was the most common (59%). Mean SMA was 89.1 cm² (±34.4) and prevalence of sarcopenia and steatosis was

41.5% and 66.9%, respectively. The mean length of hospital stay was 26.7 (±21.1) days.

During two different epidemic waves, in particular from February 2020 to May 2020 (first wave) and from September 2020 to January 2021 (second wave), we observed a different prevalence rate of sarcopenia among patients: 57.9% vs 21.6%, respectively (p < 0.0000). Conversely, the prevalence of steatosis was similar (73.5% vs 73.3%) in both groups (Table 2). In both genders, SMA values during the second wave showed a different pattern of distribution characterized by a greater dispersion (Fig. 3).

Mean albumin concentration differed between the two groups (3.2 g/dl ± 0.5 vs 3.4 g/dl ± 0.5 p = 0.0024). We registered a different mortality between first wave group and second wave group: 14.8% vs 26.5%, respectively (p < 0.0211). Other clinical characteristics were well balanced between the two groups of patients as shown in Table 2.

In sarcopenic patients subgroup, mean albumin concentration was 3.1 ± 0.5 g/dl during the first wave and 3.4 ± 0.4 g/dl during the second wave (p < 0.0033); mean PCR was 12.2 ± 9.9 mg/dl during the first wave and 6.9 ± 7.4 mg/dl during the second wave (p < 0.0071) (Table 3). Additionally, we observed a different prevalence of steatosis between the two waves (69.7% vs 48%) (Table 3).

3.2. Role of sarcopenia

Our analysis was aimed at searching for clinical and anthropometric prognostic parameters. We evaluated the prognostic impact of body composition and steatosis, finding a significant association between sarcopenia and poor clinical outcome during first wave (HR 2.29; 95% CI 1.22 to 4.30, p < 0.0101). Following adjustment for

Table 1
General characteristics — Missing values were excluded from calculations.

Gender	M	n %	171	62.9%
Age	years	median IQR	71.0	61—78
Albumin	g/dl	mean sd	3.3	0.5
PCR	mg/dl	mean sd	9.6	9.3
Heart diseases	yes	n %	72	27.1%
Hypertension	yes	n %	157	59.0%
Cerebrovascular diseases	yes	n %	21	7.9%
Diabetes	yes	n %	61	22.9%
Dyslipidemia	yes	n %	70	26.3%
COPD	yes	n %	31	11.7%
Asthma	yes	n %	7	2.6%
CKD	yes	n %	37	13.9%
Cancer	yes	n %	59	21.7%
Endocrinopathies	yes	n %	24	8.8%
SMA	cm²	mean sd	89.1	34.4
Sarcopenia	yes	n %	113	41.5%
Steatosis	yes	n %	182	66.9%
LOS	days	mean sd	26.7	21.1
ICU admission	yes	n %	77	28.3
Death	yes	n %	54	19.9

Abbreviations: M: male, n: number, SD: standard deviation, IQR: interquartile range, PCR: c-reactive protein, COPD: chronic obstructive pulmonary disease, CKD: Chronic Kidney Disease, SMA: skeletal muscle area, LOS: length of stay, ICU: intensive care unit.

Table 2
Comparison of general characteristics in first wave and second wave. Missing values were excluded from calculations.

			1-st wave		2-nd wave		p-value
			N = 155		N = 117		
Gender	M	n %	101	65.2%	70	59.8%	0.3779
Age	years	median IQR	70.0	61–78	71.0	63–78	0.3436
Albumin	g/dl	mean sd	3.2	0.5	3.4	0.5	**0.0024**
PCR	mg/dl	mean sd	10.2	9.4	8.9	9.2	0.1951
Heart diseases	yes	n %	35	22.7%	37	33.0%	0.0699
Hypertension	yes	n %	87	56.5%	70	62.5%	0.3770
Cerebrovascular diseases	yes	n %	14	9.1%	7	6.3%	0.4925
Diabetes	yes	n %	31	20.1%	30	26.8%	0.2377
Dyslipidemia	yes	n %	42	27.3%	28	25.0%	0.7781
COPD	yes	n %	19	12.3%	12	10.7%	0.8469
Asthma	yes	n %	4	2.6%	3	2.7%	1.0000
CKD	yes	n %	21	13.6%	16	14.3%	1.0000
Cancer	yes	n %	24	15.5%	35	29.9%	0.0049
Endocrinopathies	yes	n %	13	8.4%	11	9.4%	0.8306
SMA	cm^2	mean sd	75.0	26.4	107.6	35.1	0.0000
Sarcopenia	yes	n %	88	57.9%	25	21.6%	0.0000
Steatosis	yes	n %	97	73.5%	85	73.3%	1.0000
LOS	days	mean sd	25.5	19.5	28.4	23.1	0.3033
ICU admission	yes	n %	39	25.2%	38	32.5%	0.2212
Death	yes	n %	23	14.8%	31	26.5%	**0.0211**
ICU admission + Death	yes	n %	54	34.8%	54	46.2%	0.6193

Abbreviations: M: male, n: number, SD: standard deviation, IQR: interquartile range, PCR: c-reactive protein, COPD: chronic obstructive pulmonary disease, CKD: Chronic Kidney Disease, SMA: skeletal muscle area, LOS: length of stay, ICU: intensive care unit.
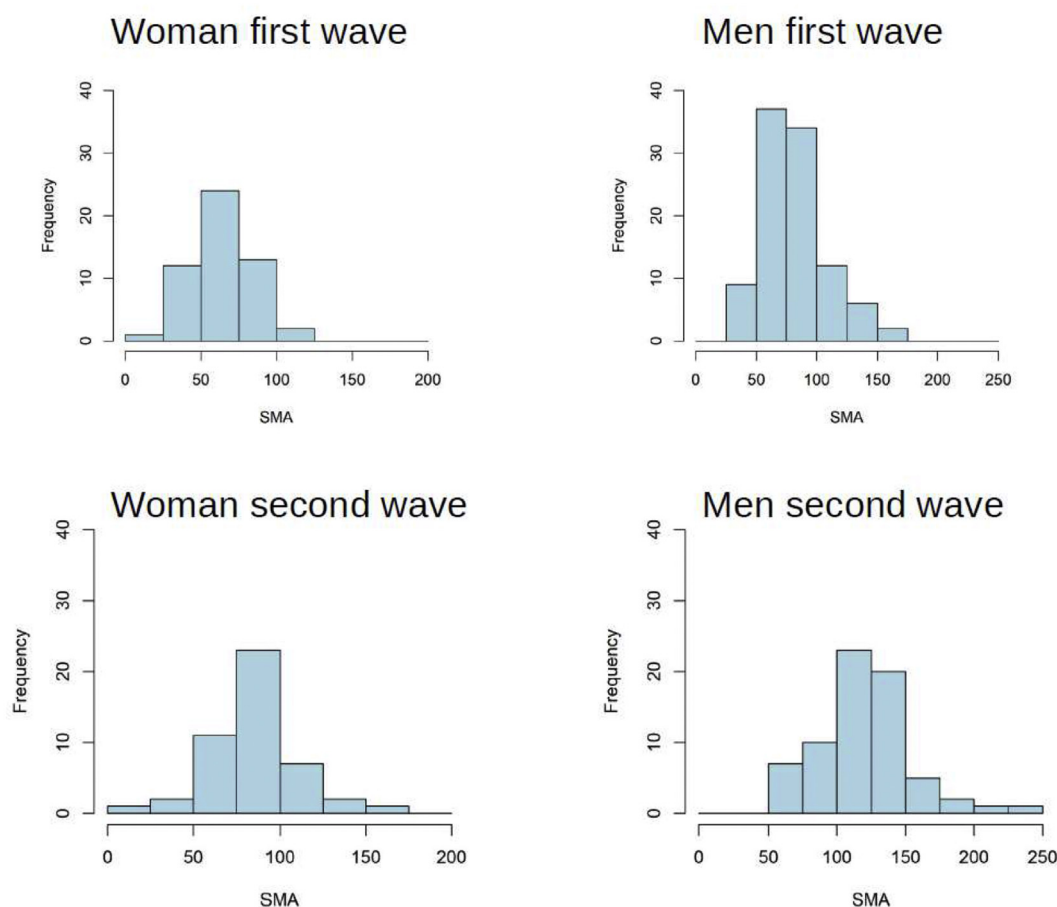Bold characters are used to stressed significant data.

Fig. 3. Different distribution of SMA values for men and women in the first and second wave.

Table 3

Comparison of general characteristics of sarcopenic patients during first and second wave: missing values were excluded from calculations.

			Sarcopenic patients				
			1-st wave n = 88		2-nd wave n = 25		p-value
Gender	M	n %	68	77.3%	12	48.0%	0.0066
Age	years	median IQR	71.0	62−78	73.0	63−84	0.3597
Albumin	g/dl	mean sd	3.1	0.5	3.4	0.4	**0.0033**
PCR	mg/dl	mean sd	12.2	9.9	6.9	7.4	**0.0071**
Heart diseases	yes	n %	19	21.6%	9	36.0%	0.1885
Hypertension	yes	n %	50	56.8%	15	60.0%	0.8223
Cerebrovascular diseases	yes	n %	11	12.5%	3	12.0%	1.0000
Diabetes	yes	n %	18	20.5%	5	20.0%	1.0000
Dyslipidemia	yes	n %	29	33.0%	3	12.0%	0.0459
COPD	yes	n %	11	12.5%	2	8.0%	0.7296
Asthma	yes	n %	2	2.3%	1	4.0%	0.5313
CKD	yes	n %	12	13.6%	2	8.0%	0.7316
Cancer	yes	n %	13	14.8%	7	28.0%	0.1433
Endocrinopathies	yes	n %	5	5.7%	3	12.0%	0.3721
LOS	days	mean sd	26.8	18.5	26.6	20.5	0.8409
SMA	cm^2	mean sd	62.3	17.5	67.8	16.7	0.1899
Steatosis	yes	n %	53	69.7%	12	48.0%	0.0577

Abbreviations: M: male, n: number, SD: standard deviation, IQR: interquartile range, PCR: c-reactive protein, COPD: chronic obstructive pulmonary disease, CKD: Chronic Kidney Disease, SMA: skeletal muscle area, LOS: length of stay.
Bold characters are used to stressed significant data.

Table 4

Univariate and Multivariate analysis for the risk of adverse clinical outcomes.

		Univariate				Multivariate			
		HR	95% CI		p	HR	95% CI		p
Sarcopenia at 1-st wave	yes vs no	2.29	1.22	4.30	**0.0101**	2.29	1.17	4.49	**0.0162**
Sarcopenia at 2-nd wave	yes vs no	0.74	0.35	1.57	0.4312	0.97	0.44	2.12	0.9345
Steatosis at 1-st wave	yes vs no	1.60	0.81	3.16	0.1741	1.64	0.82	3.29	0.1654
Steatosis at 2-nd wave	yes vs no	0.80	0.42	1.56	0.5188	0.74	0.37	1.49	0.4020
Age	+1 year	–	–	–	–	0.99	0.97	1.00	0.0916
Sex	M vs F	–	–	–	–	1.75	1.05	2.90	0.0320
Heart diseases	yes vs no	–	–	–	–	0.96	0.56	1.63	0.8727
Hypertension	yes vs no	–	–	–	–	1.38	0.86	2.20	0.1845
Cerebrovascular diseases	yes vs no	–	–	–	–	1.30	0.77	2.19	0.3243
Diabetes	yes vs no	–	–	–	–	1.62	1.00	2.63	0.0491
Dyslipidemia	yes vs no	–	–	–	–	0.97	0.44	2.16	0.9454
COPD	yes vs no	–	–	–	–	0.52	0.23	1.19	0.1205
Asthma	yes vs no	–	–	–	–	1.58	0.35	7.25	0.5539
CKD	yes vs no	–	–	–	–	1.15	0.63	2.13	0.6449
Cancer	yes vs no	–	–	–	–	1.43	0.86	2.37	0.1711
Endocrinopathies	yes vs no	–	–	–	–	0.55	0.23	1.33	0.1873

Abbreviations: HR: hazard ratio, CI: confidence interval, COPD: chronic obstructive pulmonary disease, CKD: Chronic Kidney Disease.
Bold characters are used to stressed significant data.

age, gender and comorbidities covariates, the multivariate analysis confirmed sarcopenia as the only independent prognostic factor in terms of adverse clinical outcome during the first wave (HR 2.29, 95% CI 1.17 to 4.49 p = 0.0162) (Table 4). Conversely, no association was found between steatosis or sarcopenia and clinical outcome during the second wave.

3.3. Pneumonia radiological characteristics

There were no significant differences in COVID19 severity in terms of pulmonary involvement at lung CT comparing sarcopenic vs not sarcopenic patients, either during the first and second wave. In 76% of patients in the first wave and 71% in the second wave, lung involvement was >3 lobes, indicating that the extension of lung impairment is a characteristic of COVID-19 pneumonia in both group. Carefully analyzing the lung involvement, we found common characteristics in both waves, such as a very low percentage of cases with an exclusive involvement of the central lung. On the other hand, an exclusive and typical peripheral lung involvement was present in first and second wave (32% and 29%, respectively). In light of these reasons, COVID-19 severity was not included in the multivariate analysis for risk of adverse clinical outcome. Mixed pattern with peripheral and central involvement was found to be dominant in both groups.

In relation to the type of pulmonary alteration at CT scan, the predominant aspect was that of ground glass (53%) opacities in patients of the first wave, whereas ground glass opacities associated to consolidating components (39%) or exclusive pulmonary alteration (33%) in patients of the second wave (Table 5).

Sarcopenic patients with an extended pulmonary involvement (≥3 lobes) were 80% in the first wave and 56% in the second wave (Table 6).

4. Discussion

Based on empirical data, some authors suggested that patients with sarcopenia have increased infection rates and poor prognosis during the current 2019 novel coronavirus disease epidemic [19].

Table 5
Comparison of radiological aspects of pneumonia in first and second wave: missing values were excluded from calculations.

			1-st wave		2-nd wave		p-value
			N = 155		N = 117		
Lobes	1	n %	113.0	76.4%	83.0	70.9%	0.3276
Lung consolidation	C	n %	16.0	12.3%	14.0	14.3%	0.000
	C-G	n %	45.0	**34.6%**	7.0	**7.1%**	
	G	n %	69.0	**53.1%**	39.0	**39.8%**	
	G-C	n %	0.0	0.0%	38.0	38.8%	
Distribution	C	n %	4.0	3.1%	1.0	1.0%	0.000
	C-P	n %	80.0	**61.5%**	37.0	**37.8%**	
	P	n %	45.0	34.6%	34.0	34.7%	
	P-C	n %	1.0	**0.8%**	26.0	**26.5%**	

Abbreviations: C: central, G: ground glass, P: peripheral; 1 = ≥3 lobes.
Bold characters are used to stressed significant data.

Table 6
Comparison of radiological characteristics of pneumonia in sarcopenic patients in first and second wave: missing values were excluded from calculations.

			Sarcopenic patients				p-value
			1-st wave		2-nd wave		
Lobes	1	n %	68	**80.0%**	14	**56.0%**	**0.0205**
Lung consolidation	C	n %	10	12.8%	4	20.0%	**0.0001**
	C-G	n %	29	37.2%	2	10.0%	
	G	n %	39	50.0%	9	45.5%	
	G-C	n %	0	0.0%	5	25.0%	
Distribution	C	n %	1	1.3%	0	0.0%	**0.0019**
	C-P	n %	49	62.8%	8	40.0%	
	P	n %	28	35.9%	8	40.0%	
	P-C	n %	0	0.0%	4	20.0%	

Abbreviations: C: central, G: ground glass, P: peripheral; 1 = ≥3 lobes.
Bold characters are used to stressed significant data.

Recently, the association between sarcopenia and adverse clinical outcomes in COVID-19 has been investigated in small observational studies that examined CT-defined sarcopenia in patients with SARS-CoV-2 infection: sarcopenia was found to be associated with prolonged hospital stay [22] and higher mortality [23,26]. The aim of our retrospective observational study was to investigate the prevalence of sarcopenia and the potential relationship between sarcopenic state and clinical outcome in hospitalized patients with coronavirus disease.

In our study, the prevalence of sarcopenia was high (41.5%) but significantly different in each epidemic wave (57.9% vs 21.6%); different health policies could partially explain this data. During the first wave of the pandemic, health authorities suggested to not test but only home quarantine for 14 days individuals with mild to moderate symptoms possibly related to SARS-CoV-2 infection. In this initial phase of the emergency, COVID-19 patients showed compromised general conditions (fever, pneumonia, anorexia, catabolism) at the moment of hospital admission, probably due to several days of disease and home isolation, which are considered risk factors for sarcopenia [20,21]. After the first wave of the pandemic, the structure of the health system underwent significant changes to try to stem a second wave: total number of ICU beds increased, primary care doctors were directly involved in the initial management of COVID-19 patients and an earlier hospitalization was promoted.

In our study, sarcopenia was identified as an independent negative prognostic factor (HR 2.29, 95% CI 1.17 to 4.49 p = 0.0162) only during the first epidemic wave. Conversely, no relationship was found between sarcopenia and poor clinical outcome during the second wave. These findings suggest that body composition might have an important role in predicting clinical outcome of COVID-19 patients.

Overall, 73.4% of patients presented steatosis at CT analysis, with similar incidence rates in the two waves (73.5% vs 73.3%). However, when taking into account only the sarcopenic populations in the first and second waves, the percentage of patients with steatosis was 69.7% and 48% respectively, indicating a higher incidence of hepatic steatosis in sarcopenic patients during the first wave compared to the second one.

The results of our study highlight a different risk profile between patients of the first and second wave and a strong association between sarcopenia and steatosis in the first wave. Notably, sarcopenia and steatosis are metabolic factors associated with chronic inflammatory state and malnutrition that can condition the immune response to systemic therapies and pathologies, as some authors suggested [19].

In our study, sarcopenia emerged as a significant risk factor for predisposition to COVID-19 pneumonia during the first wave, but not in the second one, indicating a different setting of patients. This relationship is not highlighted in the literature and needs confirmation in larger populations with different characteristics.

Regarding radiological characteristics and severity of COVID-19 pneumonia in the two groups, we found patterns in line with the literature: extensive lung involvement, prevalence of ground glass opacities and predominantly peripheral parenchymal involvement [25,27,28].

Interestingly, no significant difference in the pattern of lung involvement could be supported by different timings in the execution of CT in relation to the clinical course of the disease. The only relevant element is that 80% of sarcopenic patients in the first wave had a more extensive pulmonary involvement versus 56% of patients in the second wave. Sarcopenia, steatosis and extensive pulmonary involvement appeared to be mainly associated during the first wave.

In our study, COVID-19 patients showed different metabolic and pulmonary features; sarcopenia was more frequently associated with steatosis, inflammation, lower albumin and extensive lung involvement during the first wave than the second one.

Our analysis has several limitations. Firstly, the retrospective design of the study. Secondly, patients without available CT scans were excluded from our analysis, leading to a possible selection bias. Moreover, a comprehensive report of the relation between body composition parameters and adverse outcome was not available due to limited medical records about muscle strength, prealbumin level, body mass index, body weight and height, likely due to the emergency situation and the critical clinical condition of patients. These limitations prevent the functional diagnosis of sarcopenia [3]. In our retrospective study, the diagnosis of sarcopenia relied only on CT findings of 12th vertebra skeletal muscle cross-sectional areas and no muscle function evaluation (handgrip strength) was performed. Some data suggest that T12 SMA permits the diagnosis of low muscle mass and could be used to correlate sarcopenia with outcome of patients undergoing CT scans limited to the chest [14,15]. These findings definitely need to be confirmed in larger prospective studies, since the validation of T12 SMA as parameter to assess low muscle quantity or quality and to confirm the diagnosis of sarcopenia could be a useful tool in the clinical practice when abdominal CT is not available.

5. Conclusions

As reported in other different clinical settings, we highlight the prognostic impact of sarcopenia in COVID-19 patients hospitalized during the first wave of the pandemic. However, the role of sarcopenia in COVID-19 patients deserve further confirmation in larger prospective studies. T12 SMA might represent a potential tool to identify sarcopenic patients in particular settings.

Author contributions

Conception and design: Menozzi R, Valoriani F, Pecchi AR, D'amico R and Banchelli F. Analysis and interpretation of data: all authors. Statistical analysis: D'amico R and Banchelli F. Final approval of manuscript: all authors. Supervision: Menozzi R, Pecchi AR, Pantaleoni M.

Additional contributions

We are grateful to all the employees of the University Hospital of Modena, for their courageous efforts in struggling against the clinical and social COVID-19 emergency.

Institutional review board statement

The Ethical Review Board of each Institutional Hospital approved the present study. This study was performed in line with the principles of the Declaration of Helsinki.

Data availability statement

Data available on request from the authors.

Declaration of competing interest

None of the authors have conflicts of interest to disclose.

List of abbreviations

COVID-19	2019 novel coronavirus disease
SARS-CoV-2	acute respiratory syndrome coronavirus 2
L3	third lumbar vertebra
CT	computed tomography
SMA	skeletal muscle area
T12	12th thoracic vertebra
ICU	intensive care unit
CRP	C-reactive protein
D12	12th dorsal vertebra
HU	Hounsfield Unit
SD	standard deviation
IQR	interquartile range
HR	hazard ratio
M	male
n	number
COPD	chronic obstructive pulmonary disease
CKD	Chronic Kidney Disease
LOS	length of stay
C	central
G	ground glass
P	peripheral

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