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Lung ultrasound alterations six months after COVID-19 pneumonia: a descriptive study

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Abstract

Objectives The primary aim of this study was to describe the prevalence and characteristics of lung ultrasound abnormalities six months after hospital discharge for COVID-19 pneumonia.

Methods This prospective observational study included patients hospitalised with COVID-19 pneumonia between March 2020 and May 2022. Participants attended a follow-up visit between one and six months after discharge. A standardised 14-zone ultrasound protocol was applied in all cases. Clinical variables and symptoms, including dyspnoea graded using the *modified Medical Research Council* (mMRC) scale, were recorded.

Results The median time from discharge to follow-up assessment was 75 days. Lung involvement on ultrasound was frequent, observed in 79.3%. The most common findings were pleural line irregularities with B-lines (75.9%) and subpleural consolidations (35.6%). A B-line count ≥ 3 per segment was noted in 38.3%. Abnormalities were more common in the basal lung regions. Dyspnoea was the main respiratory symptom, reported by 67% with varying degrees on the mMRC scale.

Conclusions COVID-19 pneumonia remains a significant public health concern, particularly among high-risk groups susceptible to severe disease and post-COVID sequelae. Efficient screening methods are needed for evaluating potential sequelae. The technical features of lung ultrasound—its accessibility, safety, reproducibility, and ability to detect pulmonary abnormalities during post-COVID follow-up—may render it a valuable tool for patient monitoring. In our series, lung ultrasound findings (pleural line irregularities, B-lines, and subpleural consolidations) were frequent. However, further studies correlating sonographic findings with associated factors and persistent symptoms are required to confirm and validate its role in this setting.

Keywords SARS-CoV-2, COVID-19, Lung ultrasonography, Outcomes, Sequelae, Post-COVID pulmonary findings

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Introduction

SARS-CoV-2 (COVID-19) disease emerged in December 2019 in the city of Wuhan and rapidly spread across the globe [1]. As of November 2024, more than 776.8 million cases of COVID-19 have been reported worldwide, with over 7 million deaths attributed to the disease—most of them occurring between 2020 and 2022 [2].

The infection can lead to a broad spectrum of pulmonary involvement, ranging from asymptomatic cases to acute respiratory distress syndrome, respiratory failure, and death. Lung ultrasound has been widely employed in the evaluation of acute infection due to its practicality and bedside availability. Its application in emergency department triage and in monitoring disease progression during hospitalisation and intensive care unit (ICU) admission has proven beneficial [3].

Chest computed tomography (CT) is considered the gold standard for identifying pulmonary abnormalities [4]. Radiological findings of COVID-19 pneumonia on CT typically include ground glass opacities, thickening of interlobular septa and subpleural space, consolidations, reticular pattern, traction bronchiectasis and/or bronchioloectasis, architecture distortion, and honeycombing [5–7]. Several studies have demonstrated high concordance between CT and lung ultrasound in the diagnosis of COVID-19 pneumonia [8–10], as well as for detecting pulmonary changes during follow-up after hospital discharge [11–14]. Lung ultrasound offers several advantages: it is a rapid, widely available, low-cost tool that can be performed at the point of care, does not involve ionising radiation, and has a relatively short learning curve [15]– [16].

The primary objective of this study is to describe the prevalence and characteristics of lung ultrasound abnormalities in patients attending a follow-up consultation after hospitalisation for COVID-19 pneumonia. A secondary objective is to assess the frequency of persistent symptoms in these individuals.

Methods

This was an observational prospective study that included subjects who received hospital care for COVID-19 pneumonia between March 2020 and May 2022. The study population comprised discharged patients, all of whom were scheduled for evaluation at a follow-up visit conducted between the first and sixth month post-discharge. Those who died during hospitalisation were not eligible for follow-up assessment, and some patients may have been lost due to transfer to other centres or cities, although precise data on these cases were unavailable.

The selection and follow-up process, as well as the design and manuscript preparation, adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [17].

Inclusion criteria

- Age ≥ 18 years.
- Hospital admission for COVID-19 pneumonia with radiological confirmation.
- Laboratory confirmation of SARS-CoV-2 infection by PCR or antigen test from a nasopharyngeal swab.
- Evaluation performed at the post-COVID-19 follow-up clinic between 1 and 6 months after hospital discharge.

Chest ultrasound

All patients underwent thoracic ultrasound using the SonoSite LX system, equipped with both linear (high-frequency ≥ 7 MHz) and convex (low-frequency 2.5–5 MHz) probes. The 14-zone scanning protocol described by Soldati et al. [18] was applied. All examinations were performed by two investigators (FNR and CAM), each with more than five years of experience in clinical and thoracic ultrasound and specific training obtained through clinical fellowships and accredited educational programmes.

An internal protocol was established to standardise the ultrasound technique and data recording. Representative images were stored and independently reviewed by a second observer. In cases of discrepancy, findings were jointly reviewed until consensus was reached. Although a formal interobserver agreement analysis was not performed, this procedure was implemented to maximise consistency and accuracy in image interpretation. The number of technically inadequate scans or regions without adequate acoustic windows was also recorded.

For each of the thoracic regions, the ultrasound findings were recorded:

- A smooth, continuous, and regular pleural line accompanied by A-lines.
- A discontinuous and irregular pleural line, which may be associated with the presence of B-lines.
- Presence of ≥ 3 B-lines per lung segment.
- Subpleural consolidations, classified by size (< 1 cm or ≥ 1 cm).

Additionally, the distribution pattern of abnormalities (unilateral/bilateral; basal/mild/upper zones) and the number of affected regions were recorded.

Secondary variables

Demographic (age and sex), anthropometric, baseline characteristics, and clinical variables were collected. Overweight and obesity were defined according to the World Health Organization (WHO) classification [19]: a body mass index (BMI) 25–29.9 kg/m² for overweight, and BMI ≥ 30 kg/m² for obesity.

From the acute infection phase, data included hospital stay duration, intensive care unit (ICU) admission, severity of pneumonia, and bacterial superinfection (defined as pathogen isolation in bronchoaspirate cultures and/or elevated procalcitonin ≥ 0.5 ng/mL).

The severity of the pneumonia episode was assessed using two validated prognostic scores: the MuLBSTA score [20] (Multilobar infiltrate, Lymphopenia, Bacterial co-infection, Smoking history, Hypertension, and Age ≥ 60 years), which predicts mortality from viral pneumonia; and the CURB-65 score [21] (Confusion, Urea, Respiratory rate, Blood pressure, and Age ≥ 65 years), which stratifies disease severity and estimates mortality risk in community-acquired pneumonia.

Oxygen therapy requirements during the initial episode were also recorded, and the degree of respiratory involvement was classified as follows:

- Very mild: did not require oxygen therapy.
- Mild: low-flow nasal cannula (≥ 1 and < 3 L/min).
- Moderate: higher flow nasal cannula (≥ 3 L/min) and/or oxygen delivered via face mask with a fraction of inspired oxygen (FiO_2) between 0.32 and 0.6.
- Severe: use of reservoir mask at ≥ 8 L/min flow and/or high-flow nasal oxygen therapy.
- Very severe: non-invasive mechanical ventilation and/or invasive mechanical ventilation (IMV).

At the follow-up visit, dyspnoea was assessed using the *modified Medical Research Council* (mMRC) scale, both at baseline and at follow-up (0 = no dyspnoea, 4 = severe dyspnoea) [22]. The presence of additional symptoms—respiratory, constitutional, musculoskeletal, and neuropsychiatric—was also recorded, including cough, chest pain, palpitations, asthenia, weight loss, arthralgia, myalgia, headache, memory disturbance, mood alteration, insomnia, paraesthesia, anosmia or hyposmia, hair loss, abdominal pain, nausea/vomiting, and either diarrhoeal syndrome or constipation.

Statistical analysis

A descriptive analysis was performed for all study variables. Continuous variables were expressed as mean ± standard deviation (SD) if normally distributed, or as median and interquartile range (IQR) otherwise. Categorical variables were presented as frequencies and percentages.

For comparisons between a continuous and a categorical variable, Student's *t*-test for independent samples was used when appropriate. Statistical significance was set at $p < 0.05$.

All analyses were conducted using IBM SPSS Statistics, version 29.0.2.0 (IBM Corp., Armonk, NY, USA).

Results

Baseline characteristics of the study population

During the study period, a total of 348 patients attended the post-COVID-19 follow-up clinic, of whom 261 were included in the analysis. Seventy patients were excluded: 17 for not meeting the inclusion timeframe (first evaluation before 30 days or after 180 days post-discharge) and 53 due to technically inadequate ultrasound examinations or suboptimal acoustic window (Fig. 1).

The median time from hospital discharge to follow-up evaluation was 75 days (IQR: 62–88). The temporal distribution of evaluations was as follows: 63 patients (24.1%) were assessed between 30 and 60 days, 173 (66.3%) between 61 and 120 days, and 24 (9.2%) between 121 and 180 days after discharge.

The mean age was 64.9 years (SD: 14.0), and 54.8% were male. At the time of the visit, 7.3% were active smokers and 33.0% were former smokers. The mean BMI was 28.6 kg/m² (SD: 5.4). A total of 36.4% of patients were overweight (BMI 25–29.9 kg/m²), and 36.4% were obese (BMI ≥ 30 kg/m²).

The most prevalent comorbidities were hypertension (77.9%), dyslipidaemia (39.8%), and diabetes (31.8%). Baseline clinical characteristics of the included population are summarised in Table 1.

Severity parameters of the initial episode of SARS-CoV-2 pneumonia

The median hospital stay was 9 days (IQR: 6–13).

Regarding pneumonia severity, the mean MuLBSTA score was 9.4 points (SD: 4.0), with ≥ 12 points (indicating a high mortality risk) in 31.0% of cases. The CURB-65 score was ≥ 2 in 52.5% of patients, indicating moderate-to-high severity.

In terms of ventilatory support during the acute phase:

- 49 patients (18.8%) did not require oxygen therapy,
- 99 (37.9%) required oxygen via low-flow nasal cannula (1–3 L/min),
- 60 (23.0%) received oxygen via simple face mask (4–7 L/min),
- 34 (13.0%) required a reservoir mask (≥ 8 L/min) or high-flow oxygen therapy,
- 19 (7.3%) required invasive mechanical ventilation (IMV) and admission to the ICU.

The median duration of oxygen therapy was 6 days (IQR: 8). Among patients admitted to the ICU, the mean ICU stay was 25.8 days (SD: 21.3), and the mean duration of IMV was 19.1 days (SD: 15.2).

Respiratory bacterial superinfection was documented in 30 patients (11.5%).

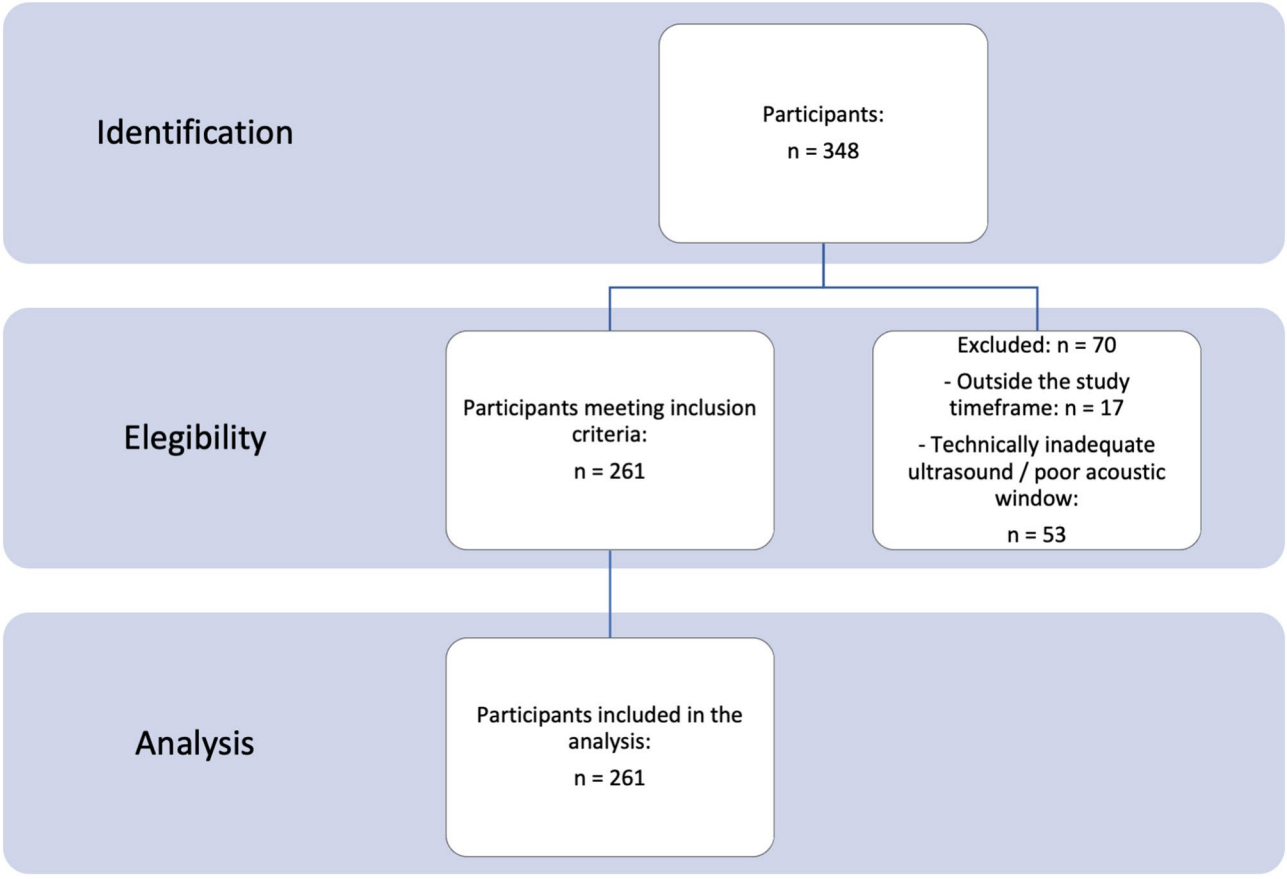

Fig. 1 STROBE Flochart of patient selection and inclusion in the six-month post-COVID-19 follow-up study

Assessment of dyspnoea and symptoms at the post-discharge follow-up visit

Dyspnoea was assessed using the mMRC scale, comparing each patient's status prior to the diagnosis of COVID-19 pneumonia with their clinical condition at the follow-up visit.

Before infection, 66.3% of patients reported no dyspnoea (mMRC = 0), while 33.7% reported some degree of dyspnoea, most frequently grade 1 (28% of cases). At the post-discharge assessment, this pattern was reversed: 67% of patients presented with dyspnoea (mMRC ≥ 1), with a significant increase observed across all levels of dyspnoea compared with baseline (Fig. 2a).

Regarding pneumonia severity, patients with persistent dyspnoea (mMRC ≥ 1) more frequently had a severe pneumonia episode, whereas those with an mMRC score of 0 at follow-up had predominantly experienced a mild episode (69.8% vs. 30.2%), with a statistically significant difference ($p = 0.004$) (Fig. 2b). This association became even more pronounced when analysing changes in mMRC score from baseline to follow-up: the greater the increase in mMRC, the higher the proportion of patients with severe pulmonary involvement ($p < 0.001$) (Fig. 2c). In this sub-analysis, Student's *t*-test confirmed significant differences in mean mMRC scores according to pneumonia severity.

Regarding persistent symptoms at the follow-up visit, the most prevalent respiratory manifestations, in addition to dyspnoea, were chest pain (19.5%) and cough (15.7%). Among the non-respiratory symptoms, asthenia was the most frequent, reported by 64.8% of patients. Neurocognitive and psycho-affective alterations, such as mood deterioration (39.8%) and memory impairment (19.5%), were also common.

Table 2 summarises the frequency of the main respiratory and non-respiratory symptoms observed at the follow-up visit.

Results of the lung ultrasound study

In the ultrasound assessment of 261 patients, lung involvement was identified in 79.3% of cases, indicating a high prevalence of persistent pulmonary abnormalities during post-COVID-19 follow-up. The involvement was bilateral in 70.1% and unilateral in 9.2% of patients.

When analysing the distribution by lung fields, the lower zones were the most frequently affected (75.1%), followed by the middle (65.9%) and upper regions (63.6%), suggesting a gravity-dependent pattern.

Table 1 Baseline characteristics of the study cohort

Variables	Outcome
Demographic and anthropometric	
Age, years (SD)	64.9 (SD: 14.01)
Males (n and %)	143 (54.8%)
BMI (kg/m^2)	28.7 (SD: 5.42)
Overweight	43.3%
Obese	36.4%
History of smoking	
Smoker	7.3%
Ex-smoker	33%
Comorbidities	
High blood pressure	77.9%
Diabetes	31.8%
Dyslipidaemia	39.8%
Atrial fibrillation	10.7%
Ischaemic heart disease	11.1%
Chronic heart failure	2.3%
COPD	4.6%
Bronchial asthma	6.9%
Cognitive impairment	6.1%
Cerebrovascular disease	6.9%
Chronic kidney disease	14.2%
Active neoplasia	5.4%
Immunosuppression	6.1%

SD standard deviation, *BMI* body mass index

Table 2 Symptomatology at the follow-up visit after COVID-19 pneumonia

Symptomatology	Frequency
Dyspnoea with mMRC ≥ 1	67%
Other respiratory or chest symptoms	
Cough	41 (15.7%)
Chest pain	51 (19.5%)
Palpitations	32 (12.3%)
General symptoms	
Asthenia	169 (64.8%)
Weight loss	37 (14.2%)
Arthralgias	36 (13.8%)
Myalgias	29 (7.7%)
Hair loss	49 (18.8%)
Neurological and psychological symptoms	
Headache	39 (14.9%)
Anosmia/hyposmia/dysgeusia	30 (11.5%)
Paresthesias	17 (6.5%)
Mnesic disorder or "mental fog" 51 (19.5%)	51 (19.5%)
Worsening of mood	104 (39.8%)
Sleep disturbances	42 (16.1%)
Digestive symptomatology	
Abdominal pain	5 (1.9%)
Nausea/vomiting	2 (0.8%)
Intestinal transit disturbance (diarrhoea)	5 (1.9%)
Disturbance of intestinal transit (constipation)	4 (1.5%)

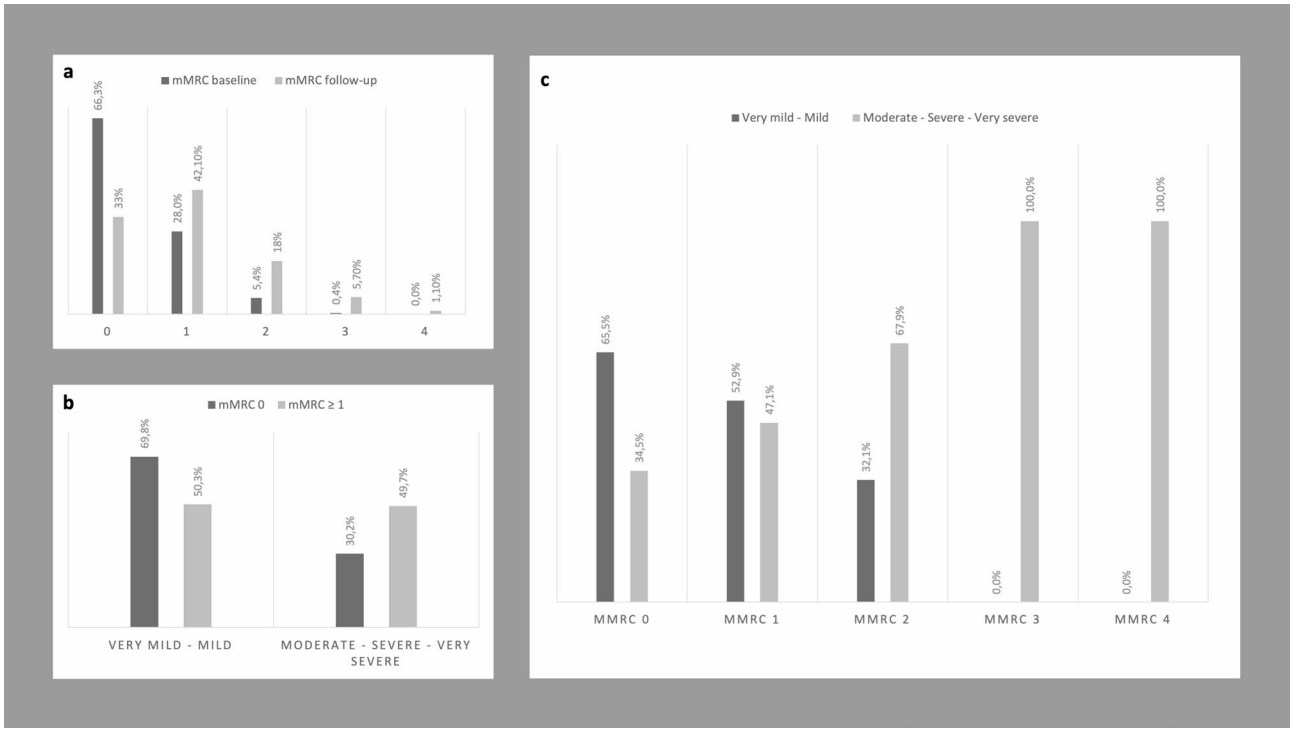

Fig. 2 Changes in dyspnoea from baseline to six months after COVID-19 pneumonia **(a)** Evolution of mMRC scale at baseline and follow-up during the first six months post-COVID-19. **(b)** Comparison between patients with no dyspnoea (mMRC = 0) and those with dyspnoea (mMRC ≥ 1) during the first six months post-COVID-19, and its association with pneumonia severity ($p = 0.004$). **(c)** Comparison between patients with no increase in dyspnoea (mMRC follow-up – baseline = 0) and those with an increase of 1, 2, 3 or 4 points in mMRC, and its association with pneumonia severity ($p < 0.001$)

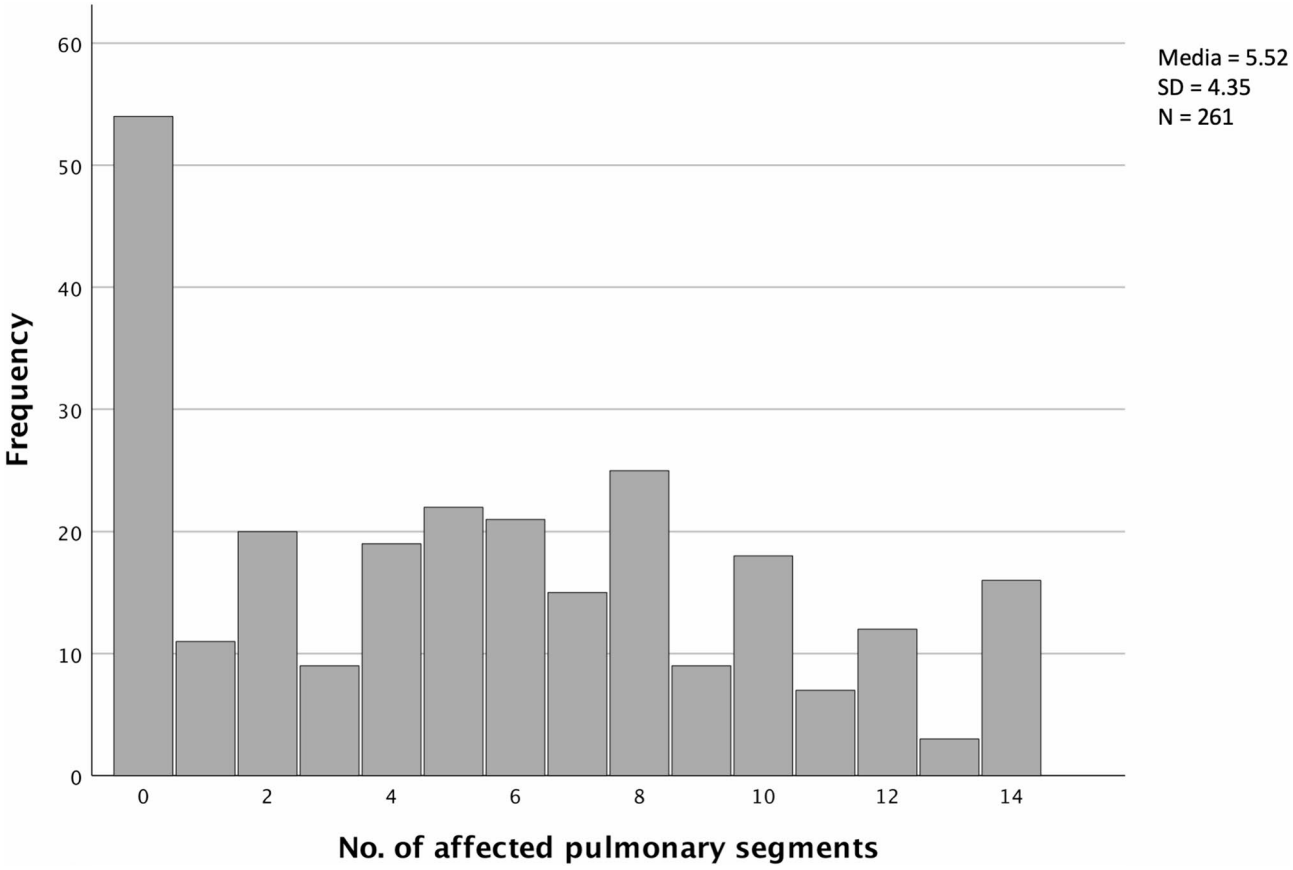

Fig. 3 Number of lung segments involved at six months in the study cohort

Table 3 Lung ultrasound findings in the first six months after COVID-19 pneumonia

Overall data (in frequency)			
Normal findings			20.7%
Ultrasound abnormalities			79.3%
Unilateral involvement			9.2%
Bilateral involvement			70.1%
Data by thoracic segments (in frequency)			
Thoracic segments	**Ultrasonographic involvement**	**Pleural line irregularities/B-lines**	**Subpleural consolidations**
Upper	63.6%	60.2%	16.1%
Middle Posteriors	65.9%	47.9%	13.4%
Lower	75.1%	73.6%	25.7%

The mean number of affected lung segments was 5.5 (SD: 4.3). No ultrasound abnormalities were detected in 54 patients (20.7%), whereas, at the opposite end of the spectrum, 16 patients (6.1%) showed diffuse involvement across all 14 evaluated regions. The extent of lung involvement was classified as moderate (1–6 affected segments) in 39.0% of cases and extensive (7–14 segments) in 40.2%. This distribution is shown in Fig. 3.

Among the ultrasound findings, the most common abnormality was pleural line irregularities associated with B-lines, observed in 75.9% of patients. Regarding the burden of B-lines per segment, a similar distribution was found between a sparse pattern (< 3 B-lines per segment, 37.5%) and a marked pattern (≥ 3 B-lines per segment, 38.3%).

Subpleural consolidations were identified in 35.6% of patients, most measuring less than 1 cm in diameter. These were predominantly located in the lower lung regions (25.7%), but were also detected in the upper zones (16.1%) and posterior midfields (13.4%). The most relevant lung ultrasound findings at mid-term follow-up after COVID-19 pneumonia are summarised in Table 3.

Overall, these ultrasound findings confirm the high prevalence of residual pulmonary structural abnormalities observed in our series during post-COVID-19 follow-up, with B-lines and pleural irregularities as the predominant features, and a slightly greater involvement of the lower lung fields. Representative ultrasound images illustrating these findings are shown in Fig. 4.

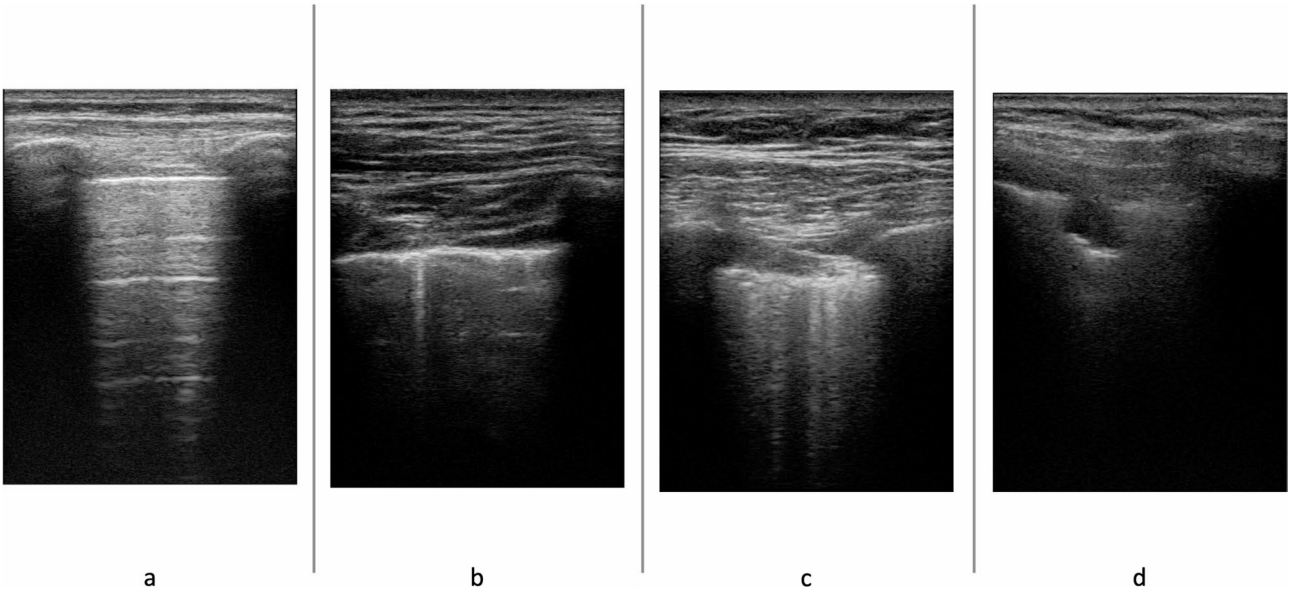

Fig. 4 Characteristics of lung ultrasound findings in the study cohort **a** Normal pattern: observed in 54/271 (20.7%). Features: Smooth, homogeneous pleural line with regular gliding; A-lines as hyperechoic horizontal lines, equidistant and parallel to the pleural line. **b** Pleural line irregularities and B-lines: observed in 198/261 (75.9%). Features: Discontinuous or interrupted pleural line; B-lines as hyperechoic, vertical artefacts perpendicular to the pleura, mobile with respiratory movement, and obscuring A-lines **c** Presence of ≥ 3 B-lines per segment: identified in 100/261 patients (38.3%). Features: Multiple vertical hyperechoic lines, mobile with pleural sliding, obscuring A-lines, with ≥ 3 per field **d** Subpleural consolidations: observed in 93/261 patients (35.6%), with a size ≥ 1 cm in 3 cases (1.1%). Features: Hypoechoic subpleural images with pleural line disruption

Discussion

In our cohort, the persistence of symptoms and the presence of structural lung abnormalities detected by chest ultrasound during the first six months after hospital discharge for COVID-19 pneumonia were common. The study population showed a balanced gender distribution and a heterogeneous range of pneumonia severity during the initial admission.

In our cohort, 79.3% of patients exhibited some abnormality on follow-up lung ultrasound. Pleural line irregularities were observed in 75.9% of cases, and B-lines in 75.9%, although a higher burden (≥ 3 B-lines per lung segment) was less common (38.3%). Subpleural consolidations were identified in 35.6% of patients. These findings are consistent with previously reported ranges for B-lines and consolidations across different follow-up periods (approximately 40–90% and 30–45%, respectively) [11–14, 23–25].

As in other series, abnormalities were slightly more frequent in the basal lung regions than in the upper segments [11, 12, 14, 26].

A recent systematic review of studies published between January 2020 and May 2023 concluded that lung ultrasound abnormalities are frequent during post-COVID-19 follow-up and correlate with the severity of the initial infection [27]. However, a key limitation identified was the heterogeneity in ultrasound techniques and in the manner in which findings were recorded across studies. The authors emphasised the need for further research using standardised protocols. In addition, most of the available evidence originates from small case series or single-centre cohorts. Our study contributes additional data obtained using a uniform 14-zone thoracic scanning protocol (proposed by Soldati et al.) [18], with an emphasis on methodological consistency in both image acquisition and interpretation.

Respiratory symptoms were predominantly characterised by dyspnoea, with some degree of mMRC ≥ 1 observed in 67% of subjects, followed by chest pain in 19.5%. Among non-respiratory symptoms, asthenia and mood disturbance were the most prevalent, occurring in 64.8% and 39.8% of patients, respectively. Studies evaluating the persistence of symptoms following COVID-19 pneumonia report dyspnoea in 40–65% of cases during the first six months, with higher prevalence among those who experienced more severe pneumonia. In our cohort, a clear relationship was identified between persistent dyspnoea at follow-up and the severity of the initial pneumonia, with a greater increase in the mMRC scores among those with more severe forms. Asthenia and mood disturbance have been reported to persist in 58% and 15–25% of patients, respectively [28, 29]. A wide range of other symptoms were observed at lower frequencies, aligning with the heterogeneous post-COVID symptom profile described in previous literature.

Our study was conducted in patients who had experienced COVID-19 pneumonia during the early phases of the pandemic, a period characterised by the circulation

of more virulent and severe SARS-CoV-2 variants. This epidemiological context likely influenced our results, as infections with these early variants were associated with an increased risk of pulmonary complications. A recent study assessing the incidence of post-acute sequelae one year after infection, taking into account the impact of viral variants and vaccination, showed that although cumulative incidence has progressively declined, the risk of developing sequelae remains significant even among vaccinated individuals. This underscores the importance of maintaining long-term follow-up for these patients [30]. Another study, which included subjects hospitalised for mild-to-moderate COVID-19 between June 2021 and April 2022, found residual lung abnormalities in 59.5% of cases at 24–30 months by thoracic CT (ground-glass opacities and fibrotic-like changes), with age identified as the main risk factor, although the study had the limitation of a small sample size [31].

Although our study corresponds to the early phases of the pandemic, it includes patients with varying degrees of pneumonia severity. Our findings provide insight into the type and distribution of ultrasound-detectable lung abnormalities during follow-up. Furthermore, the most recent evidence highlights that the groups at highest risk of developing pulmonary sequelae are older individuals, those with severe pneumonia, pre-existing comorbidities, smokers, or those exposed to environmental pollutants—emphasising the need for targeted and cost-effective monitoring strategies in these populations [32].

It is essential to acknowledge the limitations of chest ultrasound, such as its operator dependence and the need for standardisation of both the technique and image interpretation. In our study population, the high prevalence of overweight and obese individuals may have contributed to the technical challenges associated with the use of a high-frequency linear probe. Across the studies reviewed in the literature, there is considerable variability in thoracic ultrasound protocols and data collection methods, which hinders the comparability of results. In cases where patient characteristics required it, a lower-frequency probe was also used to optimise visualisation. When an adequate acoustic window could not be obtained with either the high- or low-frequency probe in any of the thoracic regions, that case was excluded from the analysis.

The implementation of harmonised protocols and structured training programmes for operators is therefore essential to optimise the performance and reproducibility of this technique. Our study followed an internal protocol aimed at standardising the ultrasound technique and data recording, which included the storage of key images and their review by a second observer. In cases of discrepancy, findings were jointly reviewed until consensus was reached. Although this procedure was implemented to ensure consistency and accuracy in image interpretation, one limitation of our work was the absence of a formal interobserver agreement analysis (kappa index). This aspect should be addressed in future studies to strengthen the reliability and interpretation of results.

Chest ultrasound appears to be a useful diagnostic tool for evaluating patients during medium- and long-term follow-up after COVID-19 pneumonia [3, 8, 14]. Further studies would be of interest to assess the correlation between ultrasound findings and potential associated factors, such as patients' baseline characteristics, the severity of the initial pneumonia episode, and persistent symptoms during post-COVID-19 follow-up. Moreover, its potential role as a prognostic tool in patients who remain symptomatic after COVID-19 pneumonia should be explored in greater depth. Such evidence could help validate the use of ultrasound as a first-line screening tool in patients who have experienced severe COVID-19 pneumonia and continue to present respiratory symptoms, potentially reducing the need for less accessible, more costly, or higher-exposure diagnostic procedures.

Conclusions

In conclusion, COVID-19 pneumonia remains a significant public health concern, particularly among high-risk groups prone to more severe disease and post-COVID sequelae. The application of validated diagnostic and prognostic tools to detect structural lung abnormalities remains highly relevant. In our study, lung ultrasound appeared to be a practical technique for identifying residual pulmonary abnormalities, as it frequently detected lung ultrasound findings such as pleural line irregularities, B-lines, and subpleural consolidations. Due to its accessibility, safety, and reproducibility, it may facilitate efficient and individualised follow-up of patients with persistent symptoms after COVID-19 pneumonia. Nevertheless, further studies correlating sonographic findings with associated factors and persistent symptoms are required to confirm and validate its role in this setting.

Abbreviations

BMI	body mass index
CT	chest computed tomography
CURB-65	Confusion, Urea, Respiratory rate, Blood pressure, and age ≥ 65 years (pneumonia severity score)
ICU	intensive care unit
IMV	invasive mechanical ventilation
IQR	interquartile range
mMRC	modified Medical Research Council scale
MuLBSTA	Multilobular infiltration, Lymphopenia, Bacterial coinfection, Smoking history, Hypertension, and Age (mortality risk score)
SD	standard deviation
WHO	World Health Organization

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statistical analysis. We are especially grateful to Dr. Francisco Rivas Ruiz for his guidance in the ethical aspects of the study, and to Dr. Javier García Alegría for his valuable clinical insight and collaboration.

Authors' contributions
FNR and CAS contributed to the assessment of the study subjects and the performance of the thoracic ultrasound. FNR and JOS contributed to the development of the database, statistical analysis and evaluation of the results. FNR and JOS contributed to the writing and editing of the manuscript.
All authors contributed to the review and editing of the manuscript and approved its submission. FNR was responsible for the decision to submit the article.

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Data availability
The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The need for ethics approval and informed consent was waived by the Ethics Committee of Costa del Sol University Hospital, in accordance with national regulations for observational studies involving anonymised data (e.g., Spanish Biomedical Research Law 14/2007). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.
Although formal written consent to participate was not required, all patients were verbally informed about the purpose of the study and provided verbal consent for the anonymous use of their clinical data for research purposes.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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