



CLINICAL, RADIOLOGICAL AND FUNCTIONAL PULMONARY SEQUELAE IN RECOVERED COVID-19 PATIENTS: AN 18-MONTH DESCRIPTIVE FOLLOW-UP STUDY

Dr. Veena. H.N^{1*}, Dr. H N Madhusudana², Dr. Sudipta Adhikari³, Dr. Nikhil Kumar^{4*}

Assistant professor¹, Department of Respiratory Medicine, KMC&RI, Hubli, India.

Professor², Department of Anaesthesia, Classified Specialist, No 6 Air Force Hospital
Coimbatore, India.

Assistant professor³, Department of Anaesthesia, Command Hospital Airforce Bengaluru, India.

Assistant Professor^{4*}, Department of Anaesthesia, Command Hospital Airforce Bengaluru, India.

***Corresponding Author:** Dr Nikhil Kumar*

*Email ID: kumar.nikhil07@gmail.com

ABSTRACT

Background: Coronavirus disease 2019 (COVID-19), caused by SARS-CoV-2, is primarily a respiratory illness but is increasingly recognized to result in persistent post-recovery sequelae, particularly involving the lungs. Survivors of moderate and severe COVID-19 frequently report prolonged dyspnoea, reduced exercise tolerance, and radiological abnormalities suggestive of residual interstitial lung disease.

Objectives: To assess clinical, radiological, and functional pulmonary sequelae in discharged COVID-19 patients and to evaluate factors influencing the severity and persistence of these abnormalities.

Methods: This descriptive observational study was conducted over 18 months at a tertiary respiratory care centre in Western Maharashtra. Fifty-seven adult patients previously hospitalized with moderate or severe COVID-19 pneumonia and hypoxaemia ($\text{SpO}_2 < 94\%$) were followed at 12, 24, and 48 weeks post-discharge. Clinical evaluation, 6-minute walk test (6MWT), pulmonary function tests (spirometry, lung volumes, DLCO), inflammatory markers, chest radiography, and HRCT chest were performed as per protocol.

Results: The mean age was 53.5 years; 70.1% were males. At 12 weeks, 95% of patients reported exertional dyspnoea, 79% fatigue, and 72% anxiety. Significant improvement was observed by 48 weeks, though 40% continued to report dyspnoea. At 12 weeks, 57.9% demonstrated desaturation on 6MWT, which reduced to 12.3% at 48 weeks. DLCO impairment was present in 80% at 12 weeks and persisted in 26% at 48 weeks. HRCT chest revealed residual reticulations in 26.3% patients at 48 weeks, suggesting post-COVID fibrotic changes.

Conclusion: Persistent pulmonary sequelae following moderate to severe COVID-19 are common and may persist up to one year post-recovery. Severity of acute illness, age, smoking history, and elevated inflammatory markers were associated with delayed recovery. Structured long-term respiratory follow-up is essential for early identification and management of post-COVID lung disease.

Keywords: COVID-19, pulmonary sequelae, DLCO, HRCT chest, long COVID, pulmonary fibrosis

INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), was first identified in Wuhan, China, in December 2019 and rapidly evolved into a global public health crisis [1]. On 11 March 2020, the World Health Organization (WHO) declared COVID-19 a pandemic owing to its high transmissibility, significant morbidity, and mortality worldwide [2]. Although the acute manifestations of COVID-19 have been well documented, increasing evidence suggests that a substantial proportion of recovered patients experience persistent or new-onset symptoms weeks to months after recovery, collectively referred to as post-COVID syndrome or long COVID [3].

SARS-CoV-2 primarily targets the respiratory system, with viral entry mediated through the angiotensin-converting enzyme-2 (ACE-2) receptor expressed abundantly on alveolar epithelial cells, vascular endothelium, and multiple extrapulmonary tissues [4,5]. Severe COVID-19 pneumonia is characterized by diffuse alveolar damage, endothelial dysfunction, microvascular thrombosis, and dysregulated immune responses, leading to acute respiratory distress syndrome (ARDS) in critically ill patients [6,7]. These pathological mechanisms form the basis for residual pulmonary abnormalities observed in survivors.

Emerging longitudinal studies indicate that pulmonary sequelae constitute the most common long-term complication following COVID-19 infection [8]. Persistent symptoms such as exertional dyspnoea, fatigue, reduced exercise tolerance, and chronic cough have been reported in 40–70% of patients even six months after recovery [9,10]. Pulmonary function testing has consistently demonstrated diffusion impairment (reduced DLCO) as the most frequent abnormality, suggesting lasting damage to the alveolar-capillary membrane [11].

Radiological studies using high-resolution computed tomography (HRCT) of the chest have identified residual ground-glass opacities, reticulations, parenchymal bands, and fibrotic-like changes in patients recovering from moderate to severe COVID-19 pneumonia [12,13]. While some of these changes regress over time, others may persist, raising concerns regarding the development of post-infectious pulmonary fibrosis [14]. Elevated inflammatory markers during acute illness—such as CRP, LDH, ferritin, and D-dimer—have been implicated as predictors of long-term pulmonary impairment [15].

Risk factors associated with persistent pulmonary sequelae include advanced age, male gender, smoking history, obesity, diabetes mellitus, hypertension, and severity of acute COVID-19 illness [16–18]. Additionally, therapeutic interventions such as prolonged corticosteroid use, high-flow oxygen therapy, non-invasive ventilation, and invasive mechanical ventilation have been linked to delayed pulmonary recovery [19].

Although several international studies have described post-COVID pulmonary outcomes, data from the Indian subcontinent remain limited, particularly with long-term follow-up extending beyond one year [20]. Given the high burden of COVID-19 in India and the distinct demographic and comorbidity profiles of Indian patients, region-specific evidence is essential to guide follow-up strategies and rehabilitation programs.

Therefore, this study was undertaken to comprehensively evaluate clinical symptoms, radiological findings, and pulmonary function abnormalities in patients discharged after moderate and severe COVID-19 pneumonia over an 18-month follow-up period, and to assess factors influencing the severity and persistence of pulmonary sequelae.

MATERIAL AND METHODS

A descriptive observational follow-up study was conducted over 18 months (January 2021–June 2022) at a tertiary care respiratory centre in Western Maharashtra.

Study Population

Adult patients discharged after hospitalization for moderate or severe COVID-19 pneumonia with documented hypoxaemia ($\text{SpO}_2 < 94\%$).

Inclusion Criteria

- Age ≥ 18 years
- Confirmed COVID-19 pneumonia
- Hypoxaemia during hospitalization

Exclusion Criteria

- Pre-existing diffuse parenchymal lung disease
- Pregnancy
- Age < 18 years
- Loss to follow-up

Follow-up Protocol

Patients were evaluated at 12, 24, and 48 weeks post-discharge with:

- Clinical assessment and MMRC dyspnoea grading
- 6-minute walk test (6MWT)
- Spirometry, lung volumes, and DLCO
- Chest X-ray at all visits
- HRCT chest when indicated and at 48 weeks

Statistical Analysis

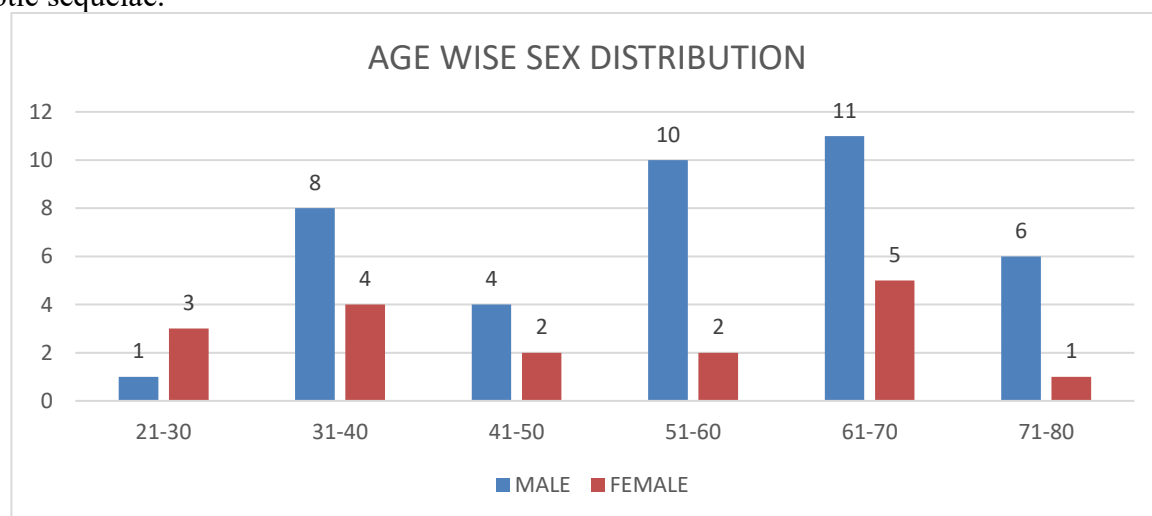
Data were analysed using descriptive statistics. Continuous variables were expressed as mean $\pm$ SD and categorical variables as percentages.

RESULTS

A total of 57 patients were followed. The mean age was 53.5 years, with males constituting 70.17%. Severe disease was documented in 52.6% patients. Obesity (42.1%), hypertension (26.3%), and diabetes mellitus (22.8%) were the most common comorbidities.

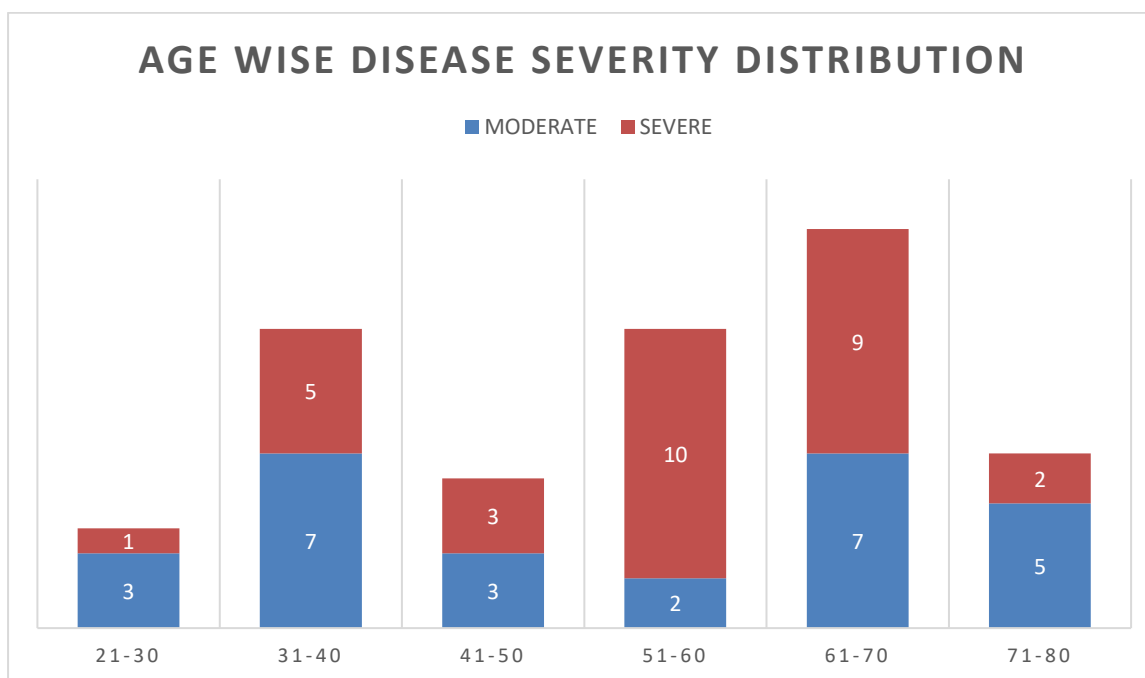
All patients demonstrated elevated inflammatory markers during hospitalization. Mean LDH was 542 IU/L, ferritin 671 ng/mL, CRP 56 mg/L, and D-dimer 1.9 μ g/mL.

At 12 weeks, exertional dyspnoea was reported by 95% patients and fatigue by 79%. Progressive symptomatic improvement occurred; however, 40% continued to report dyspnoea at 48 weeks. Significant desaturation on 6MWT was observed in 57.9% at 12 weeks and reduced to 12.3% at 48 weeks. Pulmonary function testing showed restrictive defects and diffusion impairment. DLCO abnormality was present in 80% at 12 weeks and persisted in 26% at 48 weeks. HRCT chest at 48 weeks demonstrated residual reticular abnormalities in 26.3% patients, consistent with post-COVID fibrotic sequelae.



Graph 1: Genderwise distribution of the cases

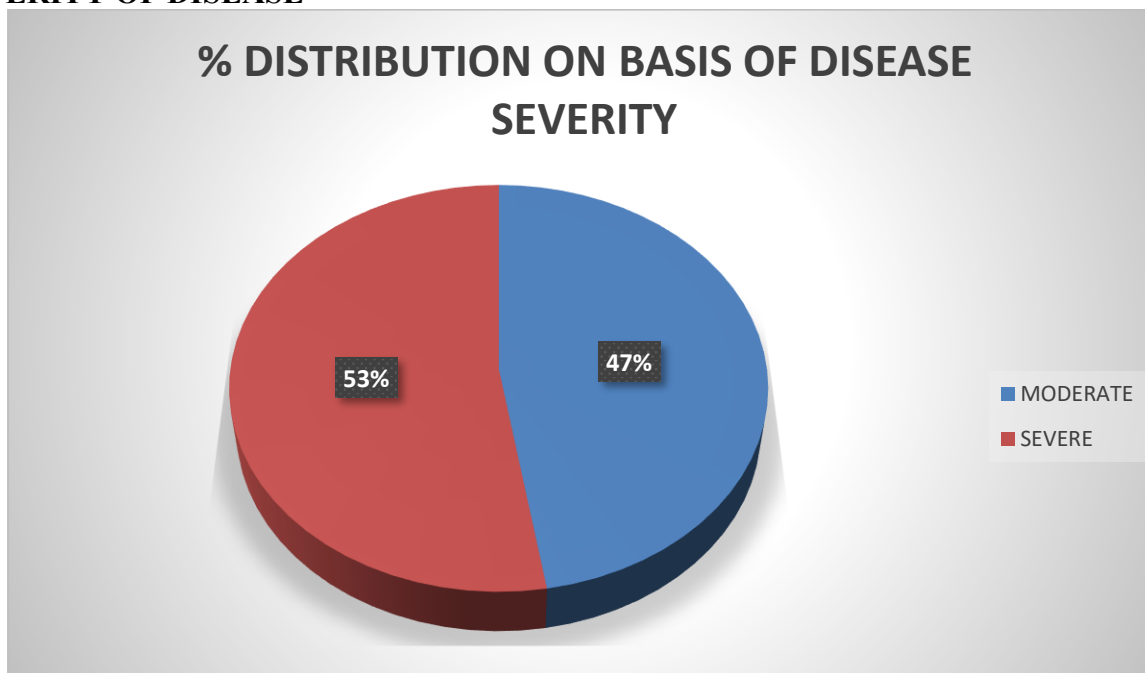
The mean age was 53.5 years. 40 (70.17 %)patients were male and 17 (29.82%) patients were female. Average age of male patients was 55.67 years and female patients was 48.64 years. Maximum number of patients were in age group 61-70 years (n=16).



Graph 2: Agewise distribution of the cases

Maximum number of patients (n=21) with severe disease were in age group of > 50 years and contributed 70% of patients with severe disease.

SEVERITY OF DISEASE

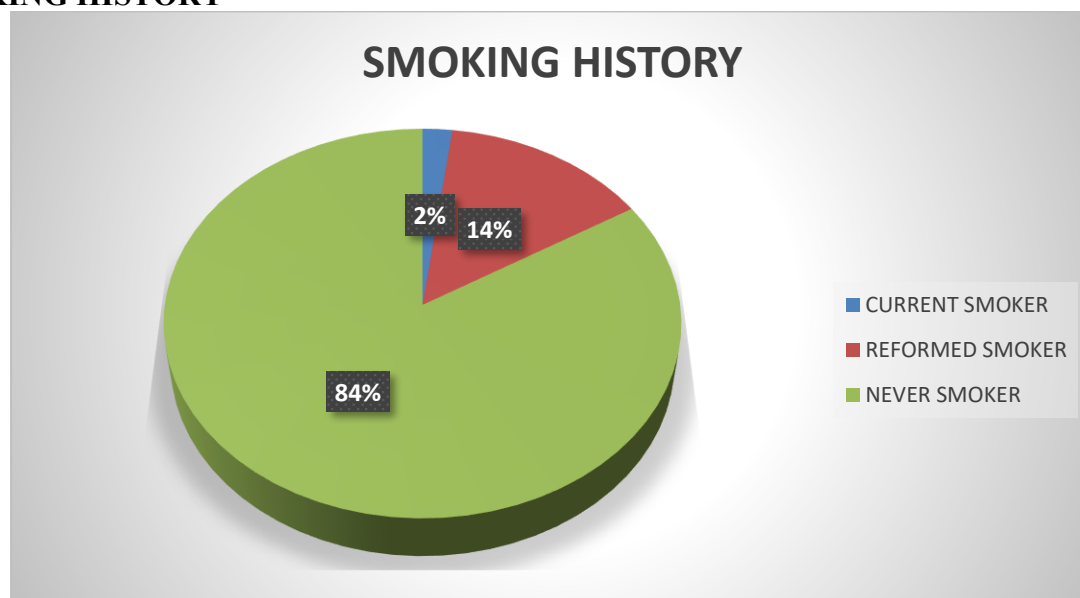


Graph 3: Distribution based on disease severity

27 (47.36%) patients had moderate disease and 30 (52.63 %) patients had severe disease. Out of 40 male patients 19 (47.5%) had severe disease and 21(52.5%) had moderate disease. Out of 17 female

patients 11(64.7%) had severe disease and 6 (54.54%) had moderate disease. Average age of male patients with severe disease was 57.10 years and female patients with severe disease was 49.72 years. Average age of male patients with moderate disease was 54.38 years and female patients with moderate disease was 46.6 years.

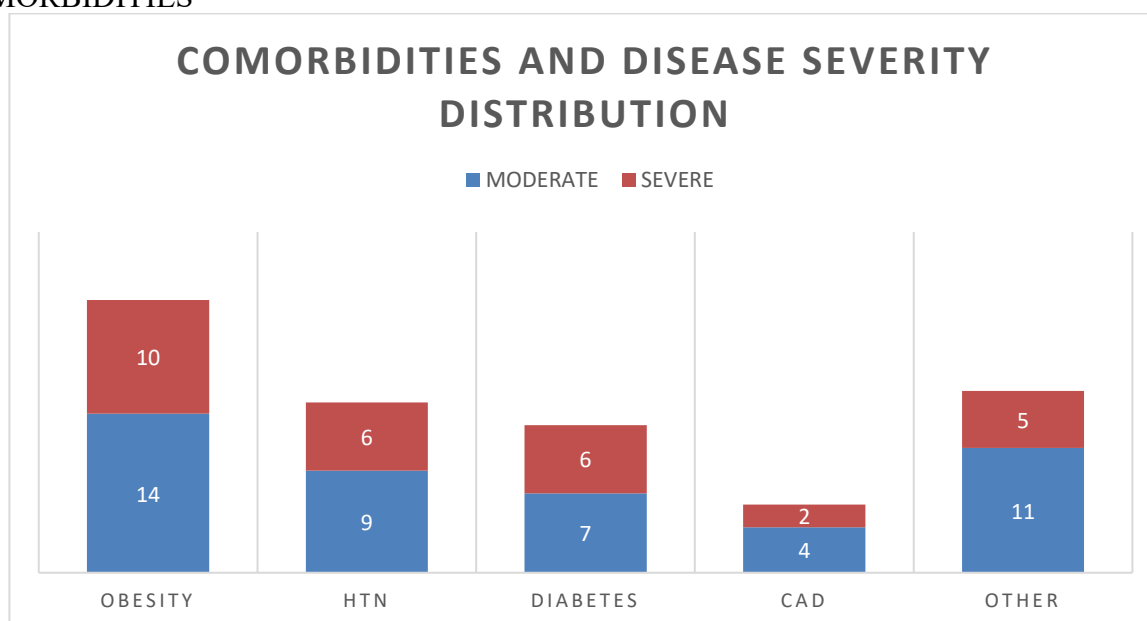
SMOKING HISTORY



Graph 4: Smoking history

It was observed that total 10 (17.54%) patients gave history of smoking, all were male, 2.5%(n=2) patients were current smokers at the time of diagnosis of COVID-19 and 14%(n=8) patient were reformed smokers. 2 patients who were current smokers, one patient developed severe disease and one patient developed moderate disease. Out of 8 patients who were reformed smokers 1 developed moderate disease and 7 developed severe disease. 47 (83.5%) patients were never smokers. Among never smokers 46.80% (n=22) developed severe disease.

COMORBIDITIES

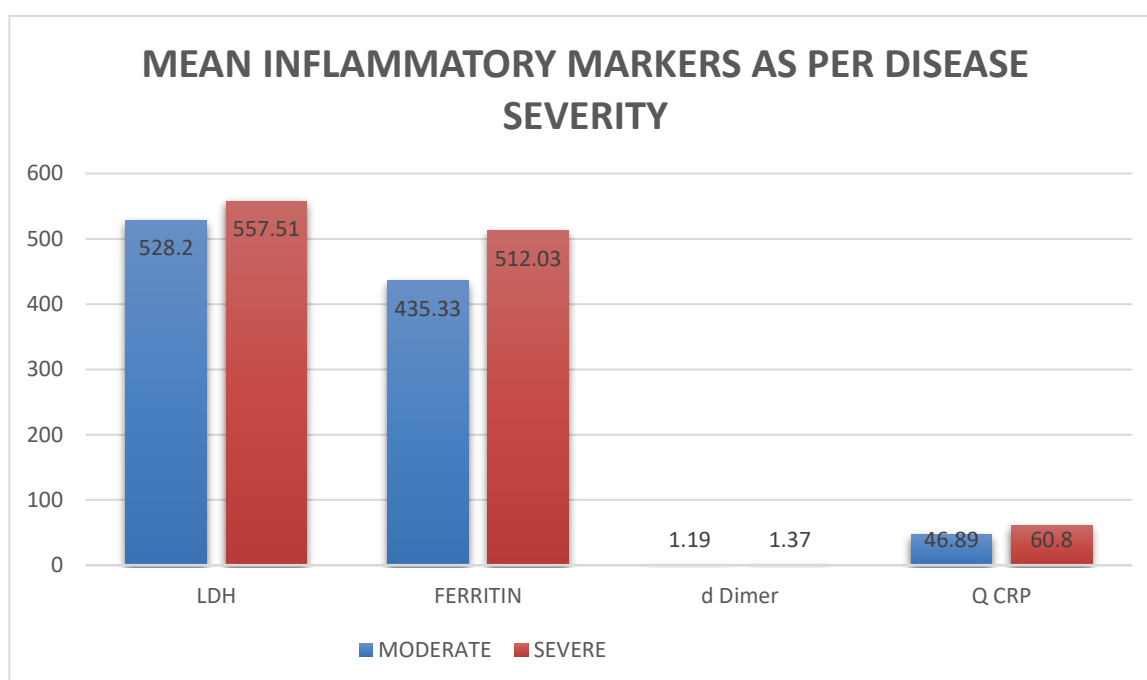


Graph 5: Distribution on comorbidities and disease severity

Most common comorbidity present was obesity (42.10%,n=24) and 41.66%(n=10) of obese patients developed severe disease. Patients with primary hypertension (26.31%,n=15), Diabetes Mellitus Type 2 (22.80%, n=13), Coronary Artery Disease (10.52%, n=6) were other major comorbidities. 16, n=28.07% patients had other miscellaneous comorbidities (Hypothyroidism-6, COPD-3, Pulmonary tuberculosis-1, Mucormycosis-1, pregnancy-1, GERD-1, CKD-3). 7 patients had two or more comorbidities and 4 patients had three or more comorbidities.

INFLAMMATORY MARKERS

Inflammatory marker	n	Minimum	Maximum	Mean	SD
LDH (IU/L)	57	215	1102	542.09	+/-182.596
FERRITIN (ng/ml)	57	263	1200	671.67	+/-193.996
D.dimer (mcg/ml)	57	.14	15.46	1.9033	+/-2.01120
CRP (mg/lit)	57	18	260	56.18	+/-40.901

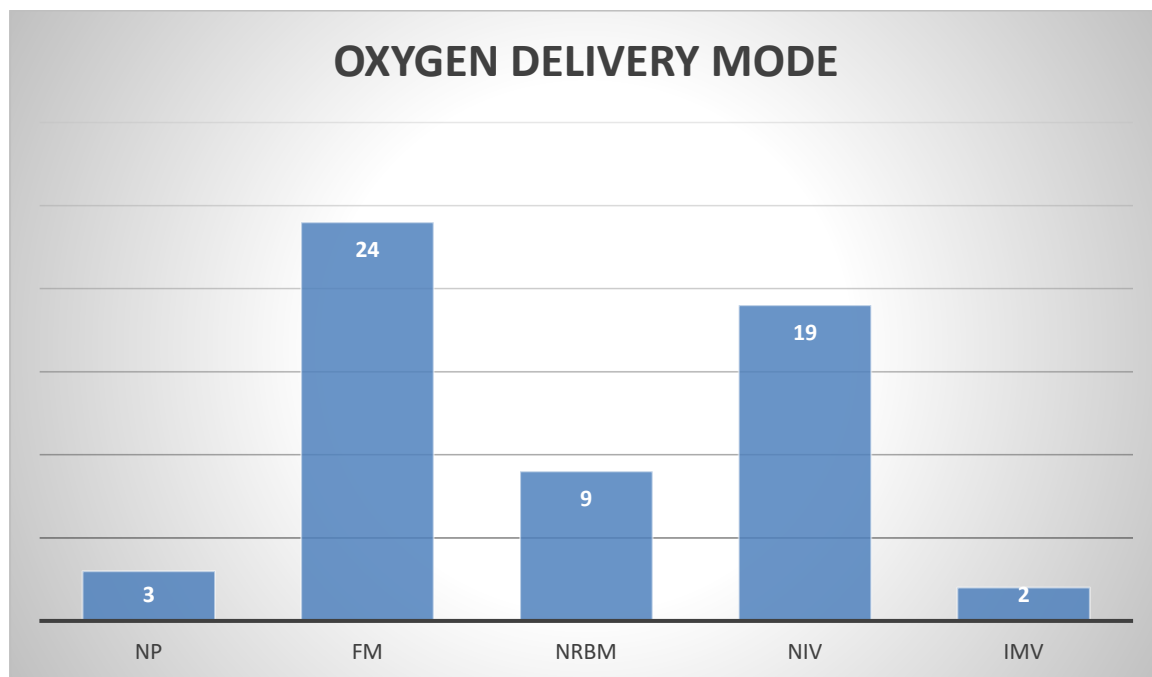


Graph 6: Mean inflammatory markers

All 57 patients had raised inflammatory markers (LDH, Ferritin, Q CRP, d Dimer) during their hospitalization period. Mean LDH was 542.09 IU/Lit (+/- 182.596), patient with severe disease had mean LDH 557.51 IU/Lit and with moderate disease 528.2 IU/Lit. The mean of ferritin was 671.67 ng/ml (+/- 193.99), with mean values 512.03 ng/ml and 435.33 ng/ml in patients with severe and moderate disease respectively. Mean of d Dimer values was 1.90 mcg/ml (+/- 2.01) with a mean value of 1.19 mcg/ml and 1.37 mcg/ml in moderate and severe disease. Mean value of CRP was 56.18 mg/lit (+/- 40.9) and mean value of 60.8 mg/lit and 46.89 mg/lit in severe and moderate disease respectively.

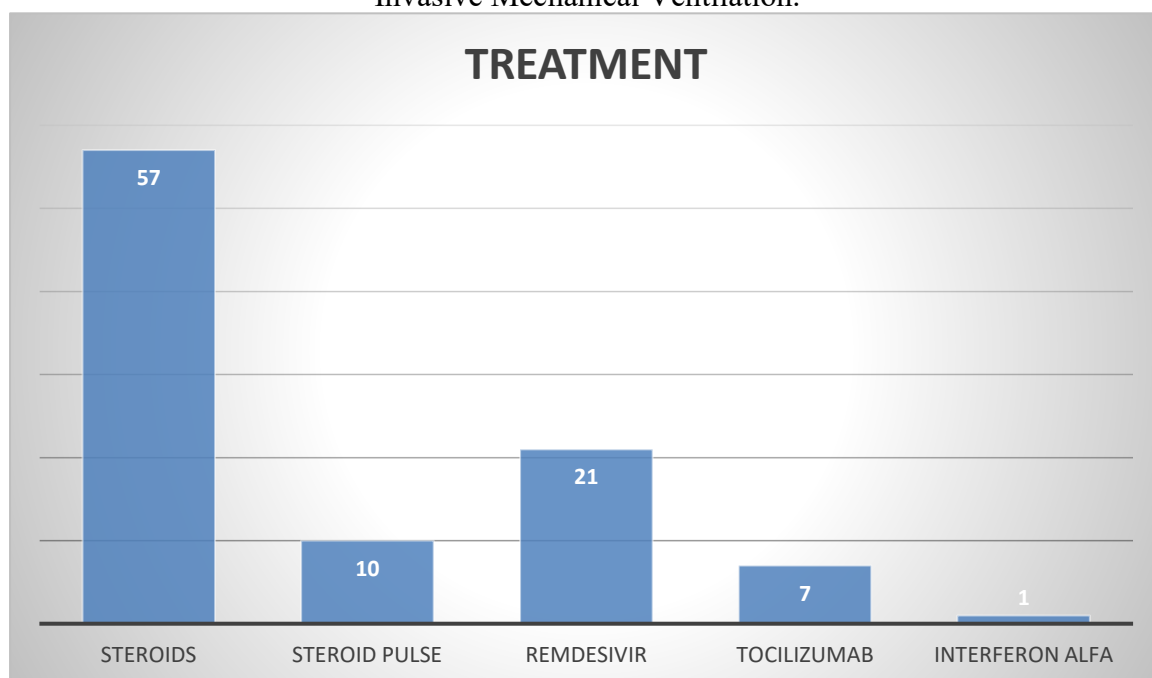
SYMPTOMS AND TREATMENT

Average duration from symptom onset to hospitalization was 4 days, and most common presenting symptoms were cough (88%), breathlessness on exertion (78.4%) and fever(82%). Patients with severe disease had late presentation to hospital with average duration from symptom onset to hospitalization 5.6 days.



Graph 7: Oxygen delivery mode

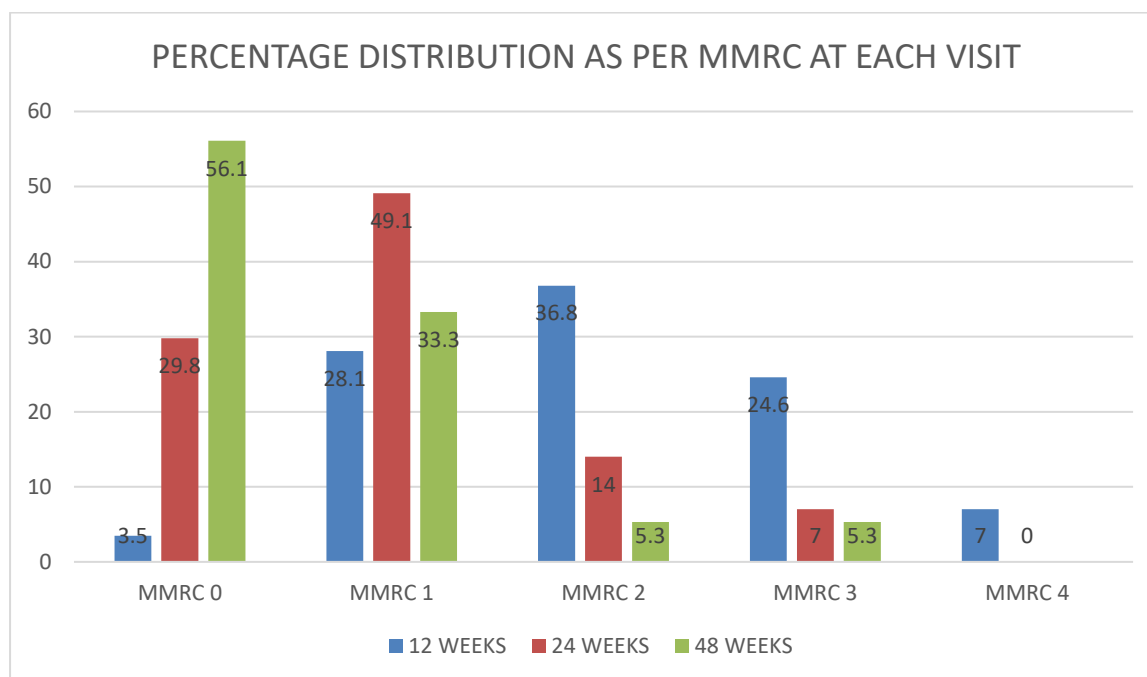
On basis of mode of oxygen delivery during hospitalization, 5.3%(n=3) patients were managed with nasal prongs, 42.1%(n=24) were managed with face mask, 15.8%(n=9) were managed with NRBM, 33.3%(n=19) were managed with Non Invasive Ventilation and 3.5% (n=2) were managed with Invasive Mechanical Ventilation.



Graph 8: Treatment

All 57 patients received steroids during their hospitalization period, 17.5% (n=10) received pulse dose of steroids. 63.2% (n=36) patients received inj. Remdesivir, 12.3% (n=7) received inj. Tocilizumab, 1.8% (n=1) patients received inj. Interferon alfa.

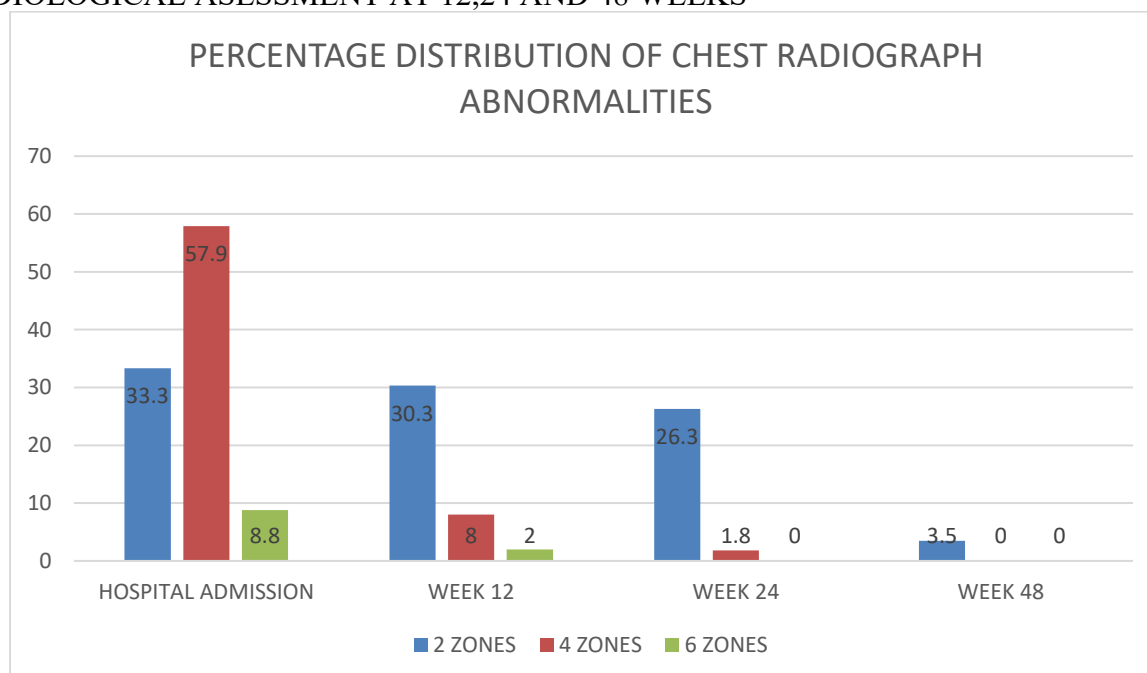
ASSESSMENT OF CLINICAL SYMPTOMS AT 12,24 AND 48 WEEKS



Graph 9: Distribution as per MMRC

Most common symptoms at 12 weeks were breathlessness on exertion (95%), fatigue (79%), anxiety (72%). At 24 weeks most common symptom was breathlessness on exertion (70%) and at 48 weeks around 40% patients complained of breathlessness on exertion. On grading the dyspnoea as per MMRC scale at 12 weeks only 4% patients had MMRC 0 and it increased to 56% patients at 48 weeks follow up. Similarly at 12 weeks follow up 7% were dyspnoeic even at rest (MMRC 4) and at 48 weeks this number reduced to 0%.

RADIOLOGICAL ASESSMENT AT 12,24 AND 48 WEEKS

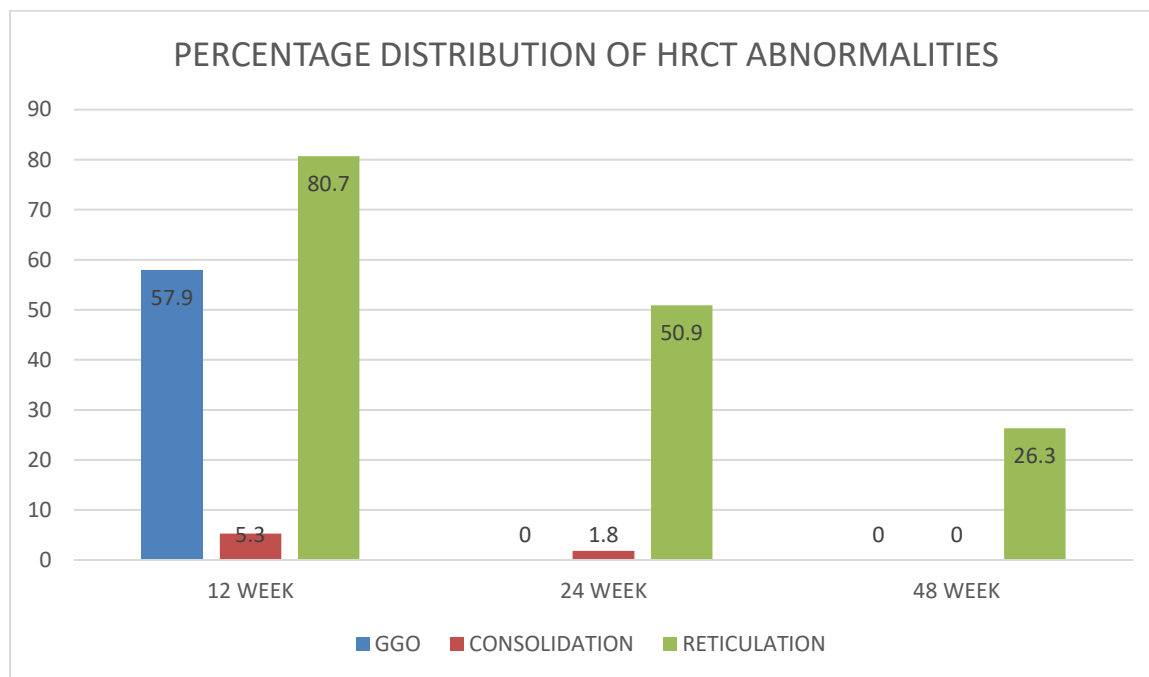


Graph 10: Distribution of chest radiography abnormalities

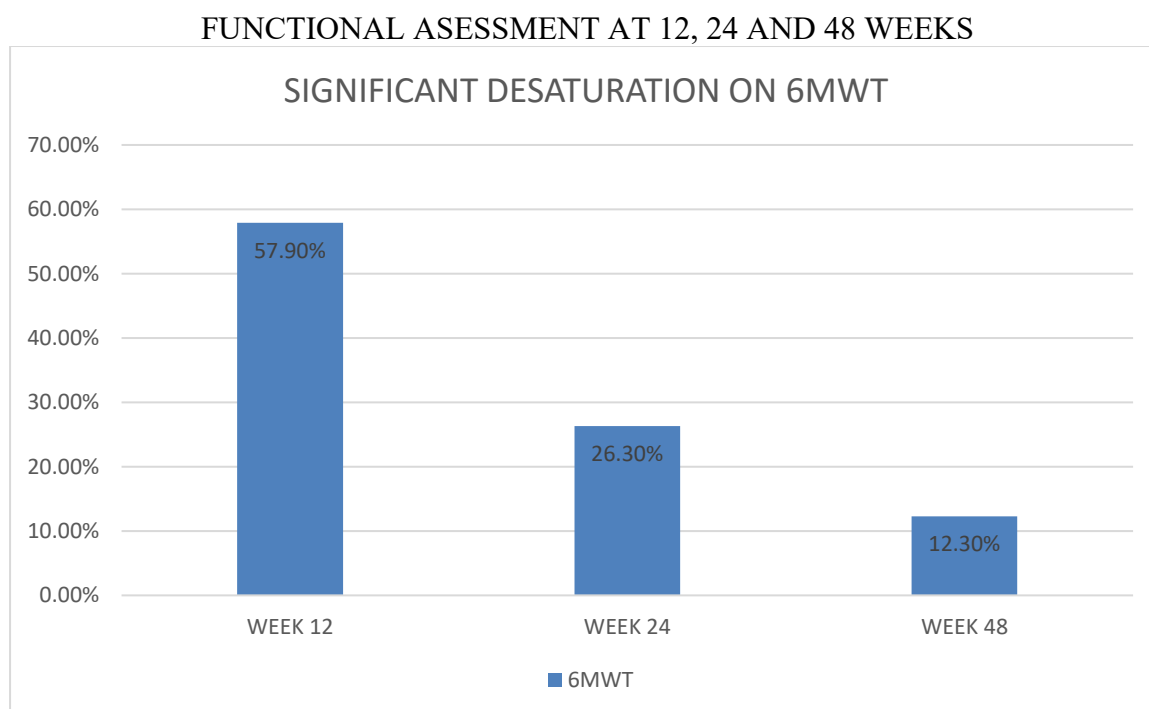
During hospital admission 33.3% patients had opacities involving 2 zones of lung, 57.9% involving 4 zones and 8.8% involving all 6 zones. At 12 weeks there was significant improvement with only

30.3% involving 2 zones, 8% involving 4 zones and 2% involving all 6 zones. There was further improvement at 24 weeks with 26.3% involving 2 zones, 1.8% involving 4 zones and at 48 weeks around 96.5% patients had complete resolution of opacities on chest radiograph with only 3.5% patients involving 2 zones of chest radiograph.

On HRCT at 12 weeks most common residual abnormality seen was reticulations (80.7%) followed by GGOs (57.9%) and only 5.3% patients had residual consolidation. At 24 weeks none of the patients had residual GGOs, 50.9% had residual reticular opacities and 1.8% (n=1) had residual consolidation which was a diagnosed case of Mucor mycosis. AT 48 weeks all patients had complete resolution of GGOs and consolidation, only 26.3% had residual reticular opacities.



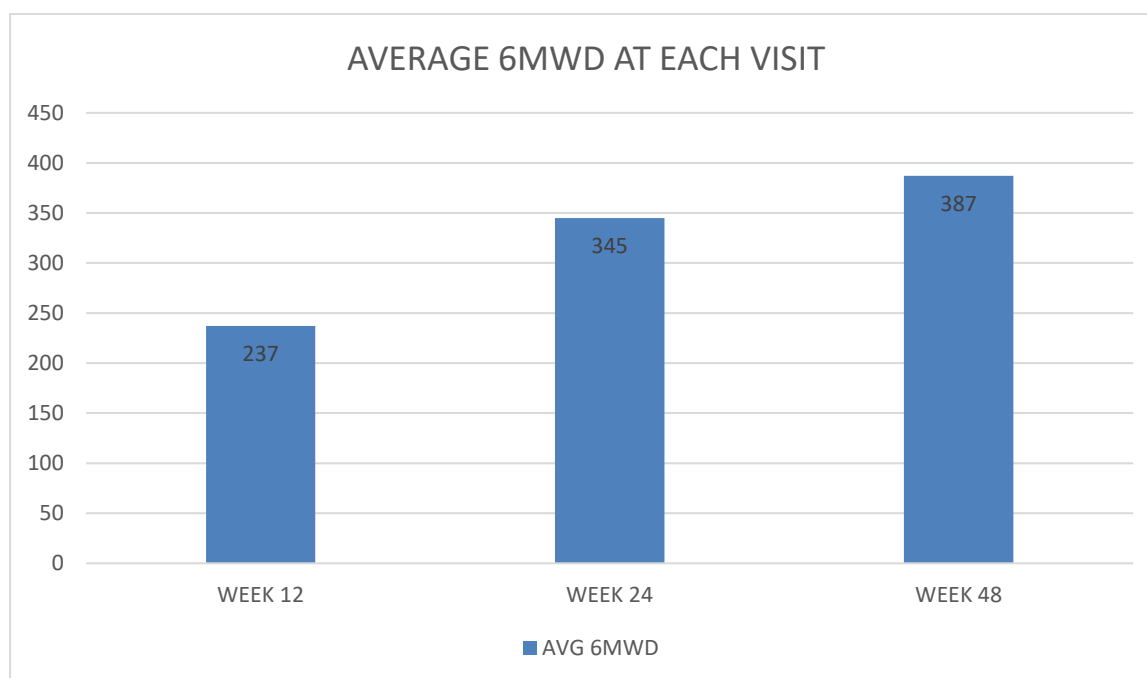
Graph 11: HRCT abnormalities



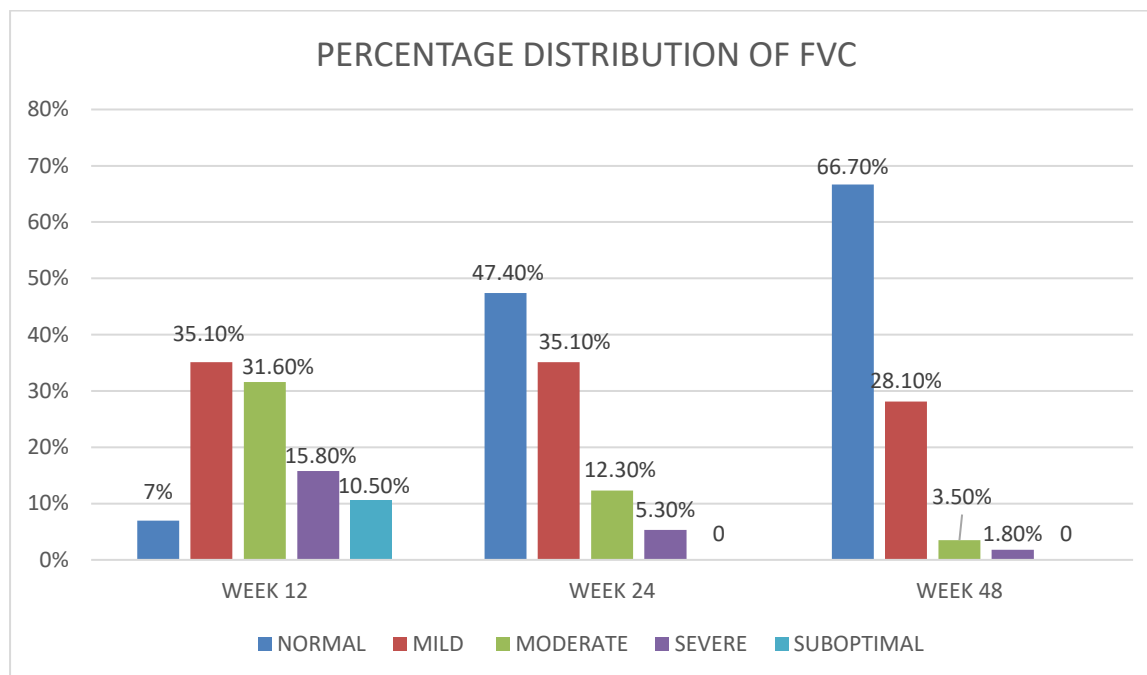
Graph 12: Desaturation on 6MWT

On 6MWT (six minute walk test) at 12 weeks 57.9% (n=33) patients had significant desaturation, mean six minute walk distance covered by these patients was 237 meters (+/-109.5 metres). At 24 weeks 26.3% (n=15) of patients had significant desaturation on 6MWT and mean 6MWD improved to 345 metres (SD +/- 99.92 metres). At 48 weeks follow up only 12.30% (n=7) patients had significant desaturation and mean 6MWD further improved to 387 metres(+/- 83.67 metres).

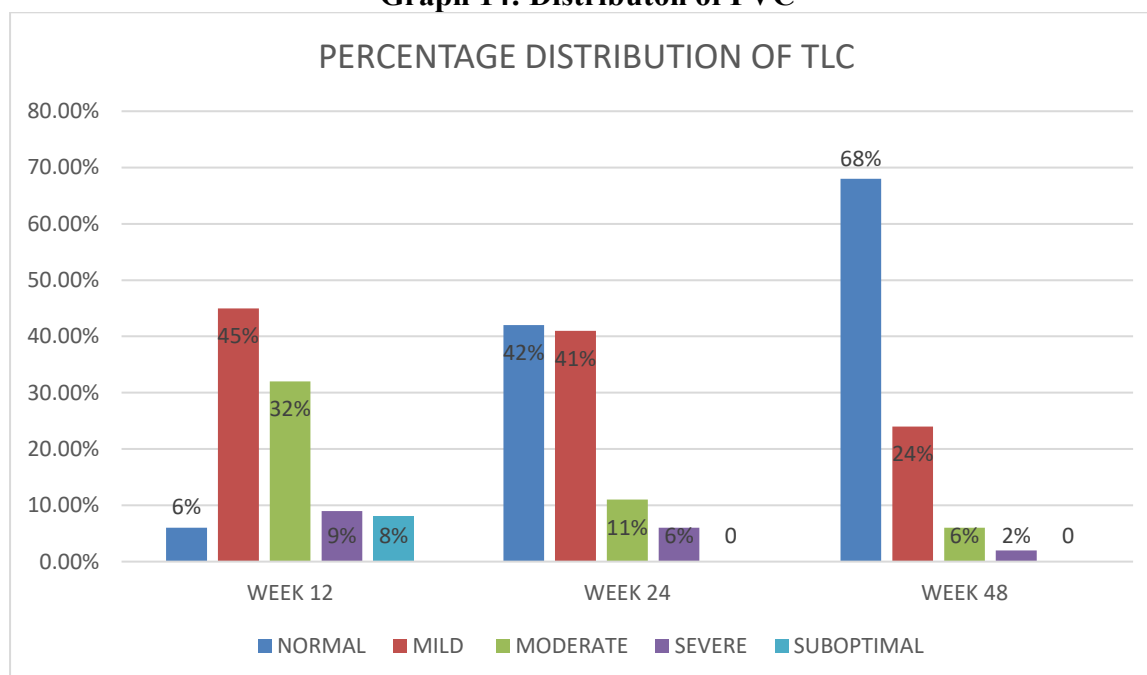
Spirometry done at 12 weeks duration, FVC was normal (>80%) in only 7% of subjects, 35.1% had mild restriction, 31.6% had moderate restriction, 15.8% had severe restriction and 10.5% subjects were unable to perform spirometry. Body plethysmography of these subjects Total lung capacity (TLC) was normal in 6% of subjects, 45% had mild restriction, 32% had moderate restriction, 9% had severe restriction and 8% had suboptimal effort. At 24 weeks, 42% subjects had normal TLC, 41% had mild restriction, 11% had moderate restriction and 6% had severe restriction. At 48 weeks, TLC was normal in 68% subjects, 24% had mild restriction and 6% moderate restriction, and 2% had severe restriction. DLCO at 12 weeks was normal in 19.80%, 52.1% had mild diffusion defect, 12.3% moderate diffusion defect and 3.5% had severe diffusion defect. 12.3% patients were unable to perform test. At 24 weeks duration, 41.9% had normal DLCO values, 47.3% had mild diffusion defect, 5.3% had moderate diffusion defect, 1.80% had severe diffusion defect and 3.5% had suboptimal effort. At 48 weeks, DLCO was normal in 74.2% patients, 20.50% had mild diffusion defect, 5.30% had moderate diffusion defect.



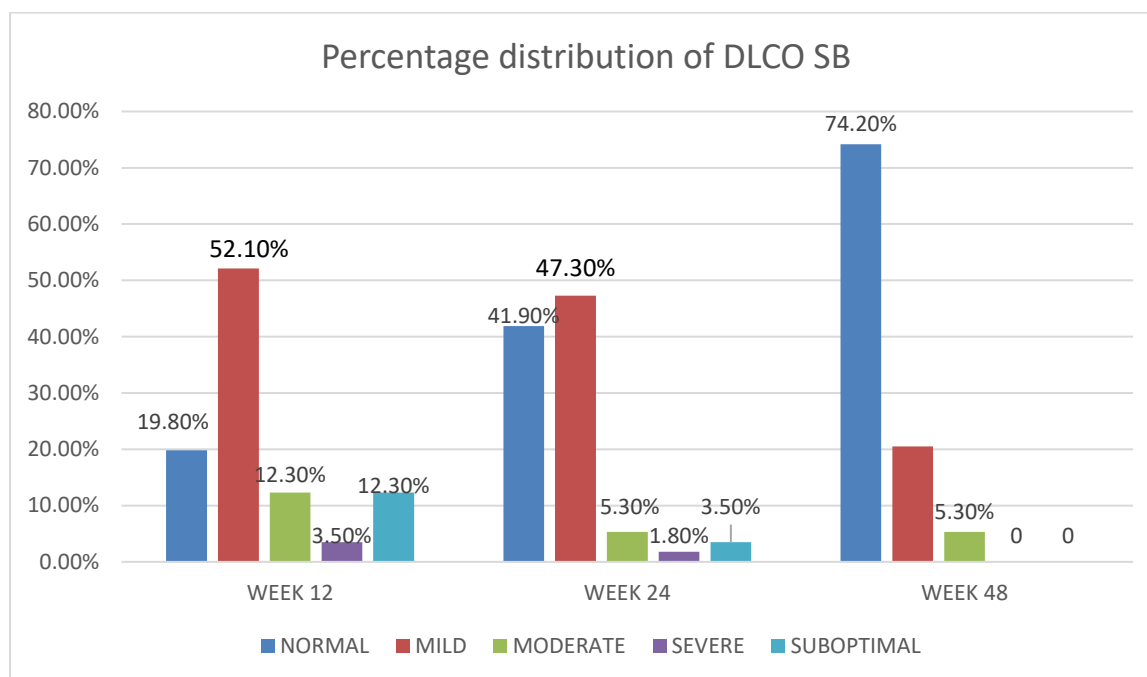
Graph 13: Average 6MWD



Graph 14: Distributon of FVC



Graph 15: Percentage of TLC



Graph 16: DLCO SB

DISCUSSION

This descriptive longitudinal study provides valuable insight into the evolution of pulmonary sequelae in patients recovering from moderate to severe COVID-19 pneumonia over a follow-up period of 48 weeks. The findings demonstrate that persistent respiratory symptoms, functional impairment, and radiological abnormalities are common following recovery, though gradual improvement occurs over time.

Demographic and Clinical Correlates

The mean age of patients in our study was 53.5 years, with a male predominance (70.17%). This demographic profile is consistent with earlier reports indicating higher hospitalization rates and severe disease among middle-aged and elderly males [18,21]. A higher proportion of severe disease was observed in patients aged above 50 years, reinforcing age as a major determinant of disease severity and delayed recovery.

Obesity, hypertension, and diabetes mellitus were the most prevalent comorbidities in our cohort, similar to findings reported in large international cohorts [22,23]. These comorbid conditions are known to exacerbate systemic inflammation, impair immune response, and predispose patients to severe pulmonary involvement, thereby increasing the risk of long-term sequelae.

Persistent Symptoms and Functional Limitation

At 12 weeks post-discharge, exertional dyspnoea was reported by 95% of patients, fatigue by 79%, and anxiety by 72%. Although there was a progressive reduction in symptom burden, 40% of patients continued to report dyspnoea even at 48 weeks. Similar persistence of symptoms has been reported by Mandal et al., where over half of patients experienced breathlessness and fatigue at 54 days post-discharge [24], and by Huang et al., who documented ongoing symptoms in 76% of patients at six months [10].

Dyspnoea in post-COVID patients is multifactorial and may result from residual parenchymal lung disease, impaired diffusion capacity, pulmonary vascular disease, deconditioning, dysfunctional breathing patterns, or underlying cardiac involvement [25]. The absence of cardiopulmonary exercise testing in our study limits definitive attribution of symptoms to a single mechanism.

Exercise Capacity and Pulmonary Function

The 6-minute walk test (6MWT) demonstrated significant impairment at 12 weeks, with 57.9% of patients showing exertional desaturation. Progressive improvement was observed, yet 12.3% continued to desaturate at 48 weeks. The improvement in mean 6-minute walk distance from 237 m at 12 weeks to 387 m at 48 weeks indicates partial functional recovery but remains lower than reported Western cohorts, possibly due to differences in anthropometric characteristics and baseline fitness [26].

Pulmonary function testing revealed restrictive ventilatory defects and diffusion impairment as the predominant abnormalities. DLCO impairment was present in 80% of patients at 12 weeks and persisted in 26% at 48 weeks. These findings align with multiple studies identifying reduced DLCO as the most consistent long-term abnormality following COVID-19 [11,27]. The persistence of diffusion defects suggests ongoing alveolar-capillary membrane dysfunction or microvascular injury.

Radiological Sequelae

HRCT chest imaging revealed residual reticulations as the most common abnormality at 12 weeks, persisting in 26.3% of patients at 48 weeks. Ground-glass opacities and consolidation resolved completely in most patients by one year. Similar patterns have been described by Sonnweber et al. and Hui et al., where fibrotic-like changes persisted in a subset of patients, particularly those with severe acute disease [13,28].

The presence of reticular abnormalities at one year may represent post-inflammatory fibrosis rather than progressive interstitial lung disease. However, the long-term clinical significance of these changes remains uncertain and warrants extended follow-up.

Role of Inflammatory Markers and Disease Severity

All patients in our cohort exhibited elevated inflammatory markers during acute illness. Higher levels of LDH, ferritin, CRP, and D-dimer were associated with severe disease and delayed pulmonary recovery. These markers reflect systemic inflammation, endothelial injury, and hypercoagulability, which are central to COVID-19 pathogenesis and subsequent organ damage [29].

Implications for Clinical Practice

Our findings emphasize the need for structured post-COVID respiratory follow-up, particularly in patients with moderate to severe disease. Pulmonary rehabilitation, early detection of diffusion impairment, and targeted management of comorbidities may improve long-term outcomes. Given the gradual but incomplete recovery observed in some patients, long-term surveillance is essential.

CONCLUSION

Pulmonary sequelae following moderate and severe COVID-19 pneumonia are common and may persist for up to one year after recovery. Although most patients demonstrate gradual clinical, functional, and radiological improvement, a significant subset continues to exhibit diffusion impairment and residual interstitial changes. Disease severity, older age, smoking history, and elevated inflammatory markers are key predictors of delayed recovery. Long-term respiratory follow-up and rehabilitation should be integral components of post-COVID care.

Limitations

- Small sample size
- Single-centre design
- Absence of baseline pre-COVID pulmonary function data
- Lack of cardiopulmonary exercise testing
- Predominant inclusion of moderate and severe cases

DECLARATIONS

Conflicts of interest: There is no any conflict of interest associated with this study

Consent to participate: There is consent to participate.

Consent for publication: There is consent for the publication of this paper.

Authors' contributions: Author equally contributed the work.

REFERENCES

1. Lu R, Zhao X, Li J, Niu P, Yang B, Wu H, et al. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. *Lancet*. 2020;395(10224):565–574. doi:10.1016/S0140-6736(20)30251-8
2. World Health Organization. WHO Director-General's opening remarks at the media briefing on COVID-19 – 11 March 2020. Geneva: WHO; 2020.
3. Nalbandian A, Sehgal K, Gupta A, Madhavan MV, McGroder C, Stevens JS, et al. Post-acute COVID-19 syndrome. *Nat Med*. 2021;27(4):601–615. doi:10.1038/s41591-021-01283-z
4. Hoffmann M, Kleine-Weber H, Schroeder S, Krüger N, Herrler T, Erichsen S, et al. SARS-CoV-2 cell entry depends on ACE2 and TMPRSS2 and is blocked by a clinically proven protease inhibitor. *Cell*. 2020;181(2):271–280.e8. doi:10.1016/j.cell.2020.02.052
5. Hamming I, Timens W, Bulthuis MLC, Lely AT, Navis GJ, van Goor H. Tissue distribution of ACE2 protein, the functional receptor for SARS coronavirus. *J Pathol*. 2004;203(2):631–637. doi:10.1002/path.1570
6. Ackermann M, Verleden SE, Kuehnel M, Haverich A, Welte T, Laenger F, et al. Pulmonary vascular endothelialitis, thrombosis, and angiogenesis in Covid-19. *N Engl J Med*. 2020;383(2):120–128. doi:10.1056/NEJMoa2015432
7. Bradley BT, Maioli H, Johnston R, Chaudhry I, Fink SL, Xu H, et al. Histopathology and ultrastructural findings of fatal COVID-19 infections. *Lancet*. 2020;396(10247):320–332. doi:10.1016/S0140-6736(20)31305-2
8. Greenhalgh T, Knight M, A'Court C, Buxton M, Husain L. Management of post-acute COVID-19 in primary care. *BMJ*. 2020;370:m3026. doi:10.1136/bmj.m3026
9. Carfi A, Bernabei R, Landi F. Persistent symptoms in patients after acute COVID-19. *JAMA*. 2020;324(6):603–605. doi:10.1001/jama.2020.12603
10. Huang C, Huang L, Wang Y, Li X, Ren L, Gu X, et al. 6-month consequences of COVID-19 in patients discharged from hospital. *Lancet*. 2021;397(10270):220–232. doi:10.1016/S0140-6736(20)32656-8
11. Mo X, Jian W, Su Z, Chen M, Peng H, Peng P, et al. Abnormal pulmonary function in COVID-19 patients at time of hospital discharge. *Eur Respir J*. 2020;55(6):2001217. doi:10.1183/13993003.01217-2020
12. Han X, Fan Y, Alwalid O, Li N, Jia X, Yuan M, et al. Six-month follow-up chest CT findings after severe COVID-19 pneumonia. *Radiology*. 2021;299(1):E177–E186. doi:10.1148/radiol.2021203153
13. Sonnweber T, Sahanic S, Pizzini A, Luger A, Schwabl C, Sonnweber B, et al. Cardiopulmonary recovery after COVID-19: an observational prospective multicentre trial. *Eur Respir J*. 2021;57(4):2003481. doi:10.1183/13993003.03481-2020
14. George PM, Wells AU, Jenkins RG. Pulmonary fibrosis and COVID-19: the potential role for antifibrotic therapy. *Lancet Respir Med*. 2020;8(8):807–815. doi:10.1016/S2213-2600(20)30225-3
15. Mazzoni A, Salvati L, Maggi L, Capone M, Vanni A, Spinicci M, et al. Impaired immune cell cytotoxicity in severe COVID-19 is IL-6 dependent. *J Clin Invest*. 2020;130(9):4694–4703. doi:10.1172/JCI138554

16. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19. *Lancet*. 2020;395(10229):1054–1062. doi:10.1016/S0140-6736(20)30566-4
17. Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting characteristics, comorbidities, and outcomes among hospitalized COVID-19 patients. *JAMA*. 2020;323(20):2052–2059. doi:10.1001/jama.2020.6775
18. Docherty AB, Harrison EM, Green CA, Hardwick HE, Pius R, Norman L, et al. Features of 20,133 UK patients in hospital with COVID-19. *BMJ*. 2020;369:m1985. doi:10.1136/bmj.m1985
19. Myall KJ, Mukherjee B, Castanheira AM, Lam JL, Benedetti G, Mak SM, et al. Persistent post-COVID-19 interstitial lung disease. *Ann Am Thorac Soc*. 2021;18(5):799–806. doi:10.1513/AnnalsATS.202008-1002OC
20. Mandal S, Barnett J, Brill SE, Brown JS, Denny EK, Hare SS, et al. ‘Long-COVID’: a cross-sectional study of persisting symptoms. *Thorax*. 2021;76(4):396–398. doi:10.1136/thoraxjnl-2020-215818
21. Garg S, Kim L, Whitaker M, O’Halloran A, Cummings C, Holstein R, et al. Hospitalization rates and characteristics of patients hospitalized with COVID-19. *MMWR Morb Mortal Wkly Rep*. 2020;69(15):458–464. doi:10.15585/mmwr.mm6915e3
22. Gupta A, Madhavan MV, Sehgal K, Nair N, Mahajan S, Sehrawat TS, et al. Extrapulmonary manifestations of COVID-19. *Lancet*. 2020;395(10229):1417–1428. doi:10.1016/S0140-6736(20)31284-9
23. Singh AK, Gupta R, Ghosh A, Misra A. Diabetes in COVID-19: prevalence, pathophysiology, prognosis. *Diabetes Metab Syndr*. 2020;14(4):303–310. doi:10.1016/j.dsx.2020.04.015
24. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med*. 2002;166(1):111–117. doi:10.1164/ajrccm.166.1.at1102
25. Wu X, Liu X, Zhou Y, Yu H, Li R, Zhan Q, et al. 3-month, 6-month, 9-month, and 12-month respiratory outcomes in COVID-19 survivors. *Ann Am Thorac Soc*. 2021;18(4):638–645. doi:10.1513/AnnalsATS.202006-729OC