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CORRELATION BETWEEN BREATH HOLDING TIME AND COMPUTED TOMOGRAPHY IN LONG COVID PATIENTS

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ABSTRACT

Background - In Coronavirus disease19 (COVID-19) majority of the patients had been associated with multiple organ damage. The major manifestation of COVID-19 infection is Pneumonia. Computed tomography (CT) Thorax has emerged as a diagnostic tool for assessing pulmonary involvement in COVID-19, while Breath-Holding Time (BHT) represents a simple yet informative measure of respiratory function. The aim of the study was to explore the relationship between Breath Holding time and CT Thorax in Long COVID-19 patient.

Methods – An Ambi-directional study involving 50 Long COVID patients with CO-RADS ≥ 1.

Results – In this study population, majority were males. Among co-morbidities majority of the patients were having diabetes. The results showed a significant correlation between CO-RADS score and Breath Holding Time. Patients with higher CO-RADS scores, indicating more severe lung abnormalities on CT scans, had shorter breath holding times.

Conclusion - There is a strong correlation between CO-RADS score and Breath Holding Time in Long COVID patients, indicates that the severity of lung abnormalities on CT Thorax is associated with impaired lung function and reduced breath holding capacity. Breath Holding Time (BHT) can be used as a simple, non-invasive measure of lung function in Long COVID patients and also to follow up lung function over time.

Keywords – COVID -19, CO-RADS, Breath Holding Time, CT Thorax, Respiratory symptoms

INTRODUCTION

In the COVID-19 pandemic, most patients exhibited damage across multiple organ systems with pneumonia being the predominant clinical presentation of the infection. [1]. Long COVID, also known as post-acute sequelae of SARS-CoV-2 infection (PASC), refers to the persistence of symptoms beyond the acute phase of COVID-19 illness. More than half of the adult survivors of COVID-19 infection have 'Long COVID' [2,3]. The COVID-19 pandemic had brought about unprecedented challenges to global healthcare system, with clinical manifestations ranging from mild respiratory symptoms to severe respiratory distress. Cough and dyspnea were reported in nearly 30% of patients with Long COVID-19, including those with mild infections that do not necessitate hospitalization [4,5]. During each of the surges in COVID case rates, hospitals were under immense pressure [6,7,8]. Computed tomography (CT) Thorax has emerged as a valuable tool for assessing pulmonary involvement in COVID-19, while Breath-Holding Time (BHT) represents a simple yet informative measure of respiratory function. Based on CT Thorax, COVID-19 Reporting and Data System (CO-RADS) provides a grading system for pulmonary

involvement of COVID-19. In COVID-19 cases, the characteristic CT features typically include bilateral ground-glass opacities and consolidation with a peripheral distribution [9]. Due to the similar etiological mechanisms and CT findings, COVID-19 pneumonia may show characteristics associated with the common cold, influenza, and other coronaviruses, such as severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) [10,11,12,13,14]

Understanding the correlation between BHT and CT findings in long COVID patients has important clinical implications for risk stratification, monitoring, and management. By elucidating the relationship between functional respiratory parameters and radiological manifestations of pulmonary involvement, clinicians can better identify individuals at risk of respiratory impairment and tailor interventions to address specific deficits. Moreover, identifying reliable biomarkers of respiratory dysfunction may facilitate early detection of complications and inform therapeutic decision-making in long COVID patients.

The aim of this study is to explore the relationship between Breath Holding time and CT Thorax in Long COVID-19 patients. This sets the stage for further evaluation of the correlation between BHT and CT findings in long COVID patients, emphasizing the potential clinical implications and the need for further research in this emerging field. Following SARS-CoV-2 infection, these relationships are crucial for optimizing the treatment and care of individuals experiencing prolonged respiratory symptoms.

METHODS

It is an Ambi-directional study conducted on 50 patients at a tertiary care hospital in South India, over a period of 4 months from November 2023 to February 2024 with history of COVID 19 pneumonia and CO-RADS score ≥ 1.

BHT will be assessed using standardized protocols, with participants instructed to take a maximal inspiration and hold their breath for as long as possible while seated comfortably. The duration of breath-holding will be recorded in seconds using a stopwatch [15]

High-resolution CT scans of the chest was be performed following standard clinical protocols to evaluate pulmonary abnormalities. CT images were reviewed by experienced radiologists with specific attention to features such as ground-glass opacities, consolidation, fibrotic changes, and vascular remodelling.

INCLUSION CRITERIA –

18 years and above, who had tested RTPCR positive for COVID-19 with CO-RADS score ≥ 1.

EXCULSION CRITERIA-

Asymptomatic patients with no radiographic evidence of pneumonia, pregnant women, patients with age <18 years and patients with previous diagnosis of pulmonary disease.

STATISTICAL ANALYSIS –

The data were analysed by using statistical software (such as SPSS)

ETHICAL CONSIDERATION-

The study was approved by ethical review committee of the institution. Names and any other identifying information were removed from the final analysis sheets.

RESULTS –

A sample of 50 patients was investigated, 62% of the patients were males and 38% of the patients were females. (figure 1). Out of 50 study populations, 17 patients (34%) had diabetes, 11 (22%) had systemic hypertension, 10 (20%) had obstructive airway disease and 6 (12%) had coronary artery disease (figure 2). (Figure 3) shows the frequency distribution of CO-RADS score among population, 13 patients had CO-RADS score of 1 and 2, 14 had a score of 3 and 10 had CO-RADS of 4. (Figure 4) shows the correlation between CO-RADS score and average breath holding time, as the CO-RADS score increases, average breath holding time decreases. A declining trend is seen in CO-RADS score and mean BHT (figure 5) in which patient with CO-RADS 1 had mean BHT of 29.8s, CO-RADS 2 – 27.1s, CO-RADS 3- 22.9s, CO-RADS 4- 13.9s respectively. There is significant association between Breath Holding time and CO-RADS score (p value < 0.05).

The results showed a significant correlation between CO-RADS score and Breath Holding Time. Patients with higher CO-RADS scores, indicating more severe lung abnormalities on CT scans, had shorter breath holding.

DISCUSSION

COVID-19 Patients usually presents with hypoxemia-driven tachypnea and hyperpnea[16,17] and it also causes damage to the epithelium[18-20]. COVID-19 patients are associated with breath holding desaturation and increased radiological severity. The correlation between breath-holding time (BHT) and computed tomography (CT) findings in long COVID patients can provide valuable insights into the respiratory manifestations and potential lung involvement in this condition. For the Assessment of Lung Function, BHT is a safe, simple and non-invasive test used to evaluate lung function and respiratory reserve. It measures the individual's ability to hold their breath after a maximal inhalation. Prolonged BHT may indicate better lung function and respiratory reserve. Previous studies had shown, persistent fibrotic changes in the CT for beyond 6 months, in patients who survived severe COVID-19 [21-23] These changes are mainly associated with older age, tachycardia, longer hospital stays, non-invasive mechanical ventilation, acute respiratory distress syndrome and a higher initial chest CT score [21-23]

In the study population, majority of the patients were males (62%), similarly studies done by Teles GBDS et al [24] and Messineo L et al [25] showed male predominance. Majority of the patients had Diabetes as Risk factor (34%) followed by hypertension (22%), but study conducted by Yanamandra U et al [26] showed hypertension as the major risk factor. In the study, patients with higher CO-RADS scores, indicating more severe lung abnormalities on CT scans, had shorter breath holding times, which showed significant association between Breath Holding time and CO-RADS score (p value < 0.05), whereas study conducted by Messineo L et al [25] also showed breath-holding desaturation was associated with radiological severity. In a study conducted by Teles GBDS et al [24] the main abnormality in lung function was reduction in DLCO% predicted.

The findings of the study revealed a significant correlation between BHT and quantitative CT parameters, indicative of pulmonary involvement in long COVID patients. Specifically, decreased BHT was associated with more extensive pulmonary abnormalities observed on CT scans, including features such as ground-glass opacities, consolidation, fibrotic changes, and vascular remodelling. These results suggest that BHT, as a simple and non-invasive measure of respiratory function, may serve as a valuable clinical indicator of underlying pulmonary pathology in long COVID patients.

Limitations

Several confounding factors, such as age, smoking history, pre-existing lung conditions, and concurrent medications, may influence both BHT and CT findings independently of long COVID.

CONCLUSION

There is a strong correlation between CO-RADS score and Breath Holding Time in Long COVID patients, indicates that the severity of lung abnormalities on CT Thorax is associated with impaired lung function and reduced breath holding capacity. Breath Holding Time (BHT) can be used as a simple, non-invasive measure of lung function in Long COVID patients and also to follow up lung function over time. Breath Holding Time may be a prognostic indicator for Long COVID patients, having shorter breath holding times being associated with worse outcomes. Further evaluation, larger studies are required.

The identification of BHT as a potential biomarker of respiratory impairment in long COVID patients has important clinical implications for risk stratification, monitoring, and management. Given its simplicity and accessibility, BHT could be integrated into routine clinical assessments to facilitate early detection of respiratory dysfunction and guide interventions aimed at improving lung function and symptom management. Incorporating BHT measurements into comprehensive rehabilitation programs may help tailor therapeutic interventions, including respiratory muscle training, pulmonary rehabilitation, and physical therapy, to address specific deficits and optimize functional outcomes in long COVID survivors.

Overall, the correlation between BHT and CT findings represents a step forward in our understanding of the complex respiratory sequelae of COVID-19 and underscores the importance of comprehensive assessment strategies in the management of long COVID patients. By leveraging both functional and structural measures of

respiratory health, clinicians can optimize patient care and rehabilitation efforts, ultimately improving the long-term outcomes for individuals affected by post-acute COVID-19 syndrome.

REFERENCES –

1. Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. JAMA . 2020;323(20):2052–2059. Erratum in: JAMA. 2020;323(20):2098

2. Nalbandian A, Sehgal K, Gupta A, Madhavan MV, McGroder C, Stevens JS. Post-acute COVID-19 syndrome. Nat Med . 2021;27(4):601–615. Review.

3. Groff D, Sun A, Ssentongo AE, Ba DM, Parsons N, Poudel GR, et al. Short-term and long-term rates of postacute sequelae of SARS-CoV-2 infection: a systematic review. JAMA Netw Open . 2021;4(10):e2128568.

4. Logue JK, Franko NM, McCulloch DJ, McDonald D, Magedson A, Wolf CR, et al

. Sequelae in adults at 6 months after COVID-19 infection. JAMA Netw Open 2021;4(2):e210830. Erratum in: JAMA Netw Open. 2021;4(3):e214572.

5. Carvalho-Schneider C, Laurent E, Lemaignen A, Beaufils E, Bourbao-Tournois C, Laribi S, et al. Follow-up of adults with noncritical COVID-19 two months after symptom onset. Clin Microbiol Infect . 2021;27(2):258–263

6. McCay L Omicron: Urgent action needed on NHS staffing crisis. BMJ. 2022;376:o18. [PubMed] [Google Scholar]

7. Kadri SS, Simpson SQ. Potential Implications of SARS-CoV-2 Delta Variant Surges for Rural Areas and Hospitals. JAMA. 2021;326(11):1003–4. [PubMed] [Google Scholar]

8. Rosenbaum L Facing Covid-19 in Italy - Ethics, Logistics, and Therapeutics on the Epidemic's Front Line. N Engl J Med. 2020;382(20):1873–5. [PubMed] [Google Scholar]

9.Bao C, Liu X, Zhang H, Li Y, Liu J. Coronavirus Disease 2019 (COVID-19) CT Findings: A Systematic Review and Meta-analysis. J Am Coll Radiol. 2020 Jun;17(6):701-709. doi: 10.1016/j.jacr.2020.03.006. Epub 2020 Mar 25. PMID: 32283052; PMCID: PMC7151282.

10. Malainou C., Herold S. [Influenza] Internist (Berl) 2019;60:1127–1135. [PubMed] [Google Scholar]

11. de Wit E., van Doremalen N., Falzarano D. SARS and MERS: recent insights into emerging coronaviruses. Nat Rev Microbiol. 2016;14:523–534. [PMC free article] [PubMed] [Google Scholar]

12. Hui D.S.C., Zumla A. Severe acute respiratory syndrome: historical, epidemiologic, and clinical features. Infect Dis Clin North Am. 2019;33:869–889. [PMC free article] [PubMed] [Google Scholar]

13. Zu ZY, Jiang MD, Xu PP, et al. Coronavirus disease 2019 (COVID-19): a perspective from China. Radiology 2020:200490. [PMC free article] [PubMed]

14. Kooraki S., Hosseiny M., Myers L. Coronavirus (COVID-19) outbreak: what the department of radiology should know. J Am Coll Radiol. 2020;17:447–451. [PMC free article] [PubMed] [Google Scholar]

15.Karen Hjerrild Andreasson, Soren Thorgaard Skou, Mike Thomas, Uffe Bodtger European Respiratory Journal Sep 2019, 54 (suppl 63) PA1185; DOI: 10.1183/13993003.congress-2019.PA1185

16. Dhont S., Derom E., Van Braeckel E., Depuydt P., Lambrecht B.N. The pathophysiology of "happy" hypoxemia in COVID-19. Respir Res. 2020;21(1):198. [PMC free article] [PubMed] [Google Scholar] [Ref list]

17.Woyke S., Rauch S., Strohle M., Gatterer H. Modulation of Hb-O2 affinity to improve hypoxemia in COVID-19 patients. Clin Nutr. 2021;40:38–39. [PMC free article] [PubMed] [Google Scholar] [Ref list]

18. Evans P.C., Rainger G.E., Mason J.C. Endothelial dysfunction in COVID-19: a position paper of the ESC Working Group for Atherosclerosis and Vascular Biology, and the ESC Council of Basic Cardiovascular Science. *Cardiovasc Res.* 2020;116(14):2177–2184. [PMC free article] [PubMed] [Google Scholar] [Ref list]

19.Gu S.X., Tyagi T., Jain K. Thrombocytopathy and endotheliopathy: crucial contributors to COVID-19 thromboinflammation. *Nat Rev Cardiol.* 2021;18(3):194–209. [PMC free article] [PubMed] [Google Scholar] [Ref list]

20.Bonaventura A., Vecchie A., Dagna L. Endothelial dysfunction and immunothrombosis as key pathogenic mechanisms in COVID-19. *Nat Rev Immunol.* 2021;21(5):319–329. [PMC free article] [PubMed] [Google Scholar] [Ref list]

21.Hui DS, Joynt GM, Wong KT. Impact of severe acute respiratory syndrome SARS) on pulmonary function, functional capacity and quality of life in a cohort of survivors. Thorax. 2005;60:401-9.

22. Zhang P, Li J, Liu H. Long-term bone and lung consequences associated with hospital-acquired severe acute respiratory syndrome: a 15-year follow-up from a prospective cohort study. Bone Res. 2020;8:8.

23. Zhao YM, Shang YM, Song WB, Li QQ, Xie H, Xu QF, et al. Follow-up study of the pulmonary function and related physiological characteristics of COVID-19 survivors three months after recovery. E-Clin Med. 2020;25:100463.

24. Teles GBDS, Fonseca EKUN, Capobianco J, Yokoo P, Rosa MEE, Antunes T, Bernardes CS, Marques TC, Chate RC, Szarf G. Correlation between chest computed tomography findings and pulmonary function test results in the post-recovery phase of COVID-19. Einstein (Sao Paulo). 2023 Dec 22;21:eAO0288. doi: 10.31744/einstein_journal/2023AO0288. PMID: 38126655; PMCID: PMC10730259.

25. Messineo L, Fanfulla F, Pedroni L, Pini F, Borghesi A, Golemi S, Vailati G, Kerlin K, Malhotra A, Corda L, Sands S. Breath-holding physiology, radiological severity and adverse outcomes in COVID-19 patients: A prospective validation study. Respirology. 2022 Dec;27(12):1073-1082. doi: 10.1111/resp.14336. Epub 2022 Aug 7. PMID: 35933689; PMCID: PMC9539071.

26. Yanamandra U, Shobhit S, Paul D, Aggarwal B, Kaur P, Duhan G, Singh A, Srinath R, Saxena P, Menon AS. Relationship of Computed Tomography Severity Score With Patient Characteristics and Survival in Hypoxemic COVID-19 Patients. Cureus. 2022 Mar 4;14(3):e22847. doi: 10.7759/cureus.22847. PMID: 35382199; PMCID: PMC8977105.

FIGURE 1 – GENDER DISTRIBUTION

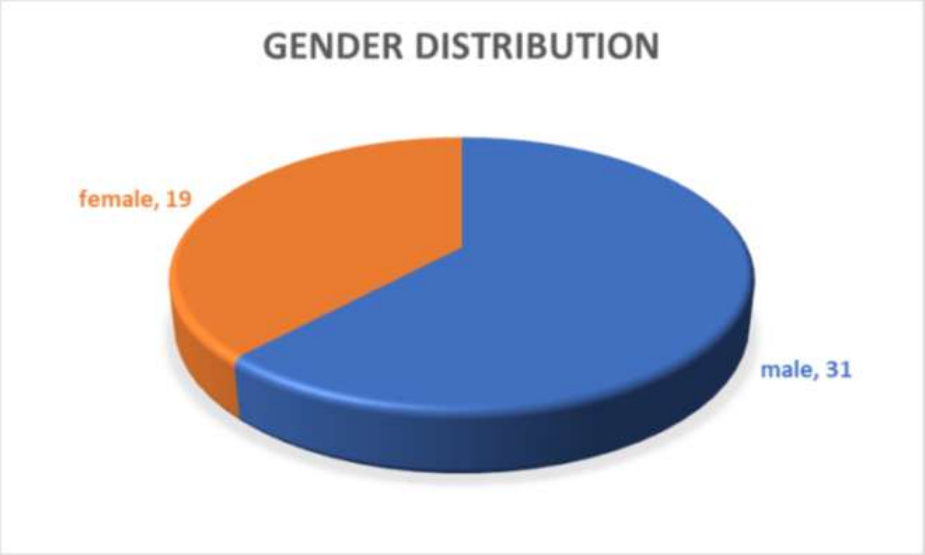

FIGURE 2 – COMORBIDITIES OF THE PATIENTS

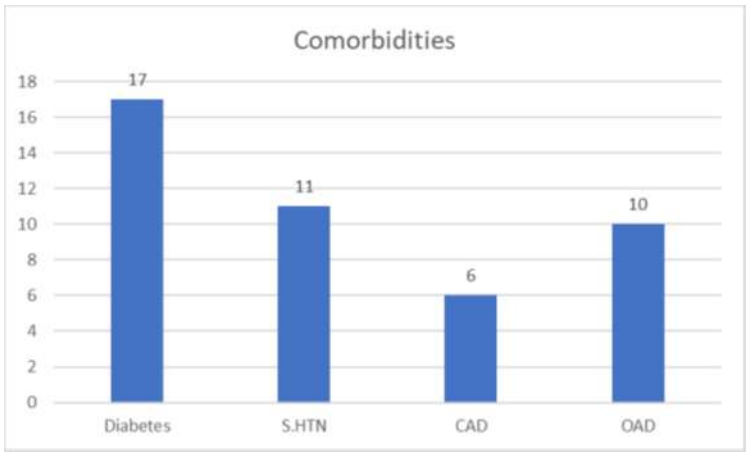

FIGURE 3- FREQUENCY DISTRIBUTION OF CO-RADS SCORE AMONG POPULATION

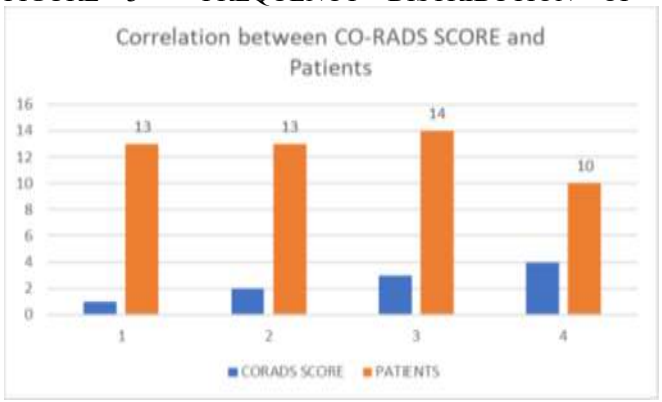

FIGURE – 4 CORRELATIOBN BETWEEN CO-RADS SORE AND BREATH HOLDING

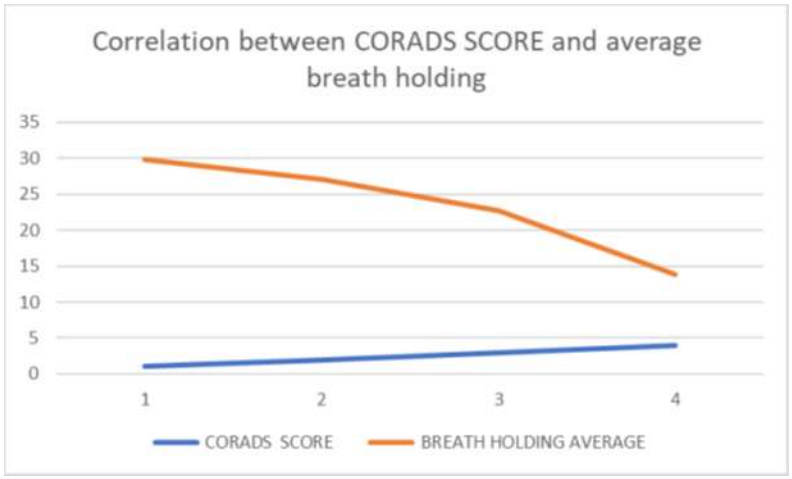

FIGURE 5 – CO-RADS SCORE AND AVERAGE BREATH HOLDING TIME.

CO-RADS SCORE	AVERAGE BREATH HOLDING TIME (SECS)
1	29.8
2	27.1
3	22.9
4	13.9