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MULTIMODALITY IMAGING OF COVID-19 PNEUMONIA : A SYSTEMATIC REVIEW

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ABSTRACT

Background: *Reversible transcription polymerase chain reaction (RT-PCR) nasopharyngeal or oropharyngeal swab tests that yield a positive result can establish the diagnosis of COVID-19. Due to the high prevalence of false-negative findings, especially in the early stages of the disease, and the patchy availability of testing, a methodical approach to diagnosis that incorporates radiologic imaging is required.*

Aims : *This systematic review is to review the multimodality imaging of patients with COVID-19 pneumonia.*

Methods: *By comparing itself to the standards set by the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, this study was able to show that it met all of the requirements. So, the experts were able to make sure that the study was as up-to-date as it was possible to be. For this search approach, publications that came out between 2014 and 2024 were taken into account. Several different online reference sources, like Pubmed and SAGEPUB, were used to do this. It was decided not to take into account review pieces, works that had already been published, or works that were only half done.*

Result: *In the PubMed database, the results of our search brought up 22.043 articles, whereas the results of our search on SAGEPUB brought up 19.007 articles. The results of the search conducted for the last year of 2014 yielded a total 173 articles for PubMed and 98 articles for SAGEPUB. In the end, we compiled a total of 6 papers, 5 of which came from PubMed and 1 of which came from SAGEPUB. We included five research that met the criteria.*

Conclusion: *In summary, owing to the SARS-CoV-2 pandemic, it is critical to understand the typical and atypical imaging features of COVID-19 pneumonia as well as how they change over time on CXR and HRCT. When evaluating hospitalized and critically sick patients in a serial fashion, as well as in places with high levels of contagion, computed tomography (CXR) may be the initial imaging modality employed*

Keyword: *Imaging, covid-19, pneumoni*

INTRODUCTION

The new coronavirus 2 that causes severe acute respiratory syndrome is the source of coronavirus disease 2019 (COVID-19). Following the confirmation of the initial diagnosis in December 2019 in the Hubei region of China, COVID-19 quickly spread around the world.[1]

Reversible transcription polymerase chain reaction (RT-PCR) nasopharyngeal or oropharyngeal swab tests that yield a positive result can establish the diagnosis of COVID-19, even in cases when the virus's clinical presentation is vague. The test is quite specific, but because of inadequate viral load or unsuccessful nucleic acid extraction, the sensitivity may be as low as 60%–70%. Due to the high prevalence of false-negative findings, especially in the early stages of the disease, and the patchy availability of testing, a methodical approach to diagnosis that incorporates radiologic imaging is required.[2,3]

PET imaging has also been investigated because of the potential role that inflammation may have in the pathogenesis and evolution of COVID-19. As of this writing, there are no published data on the pulmonary results of COVID-19 MRIs, and there are only a few case reports about cardiac-related diseases. Nevertheless, pictures are part of this review. Additionally covered is the use of echocardiography in the assessment of COVID-19 patients. Additionally, the increasing prevalence of COVID-19 extrathoracic and thrombotic symptoms is discussed.[4–6]

The spectrum of COVID-19 thoracic imaging findings at chest radiography, CT, MRI, PET/CT, US, and echocardiography is described in this multimodality imaging review (Table). The characteristics listed align with the discoveries made by previous pioneering researchers. Chest radiography can be insensitive for early or mild illness diagnosis due to its low sensitivity for detecting modest pulmonary alterations, but it can be helpful in patient triaging and care monitoring for individuals with radiographically identifiable pneumonia. It is now known that CT alterations show a temporal evolution pattern indicative of organizing pneumonia as a reaction to acute lung damage.

Chest US has been useful, especially in POC assessment, and the look matches well with CT results. Although the MRI and PET/CT results are not yet fully understood, our sample MRI and PET/CT pictures show that they closely match typical appearances seen in CT imaging. Complications from thromboembolism and extrathoracic surgery might appear in a variety of ways. The COVID-19 infection's long-term effects are yet unclear.

METHODS

Protocol

The author of this study ensured that it complied with the standards by adhering to Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines. This is done to guarantee the accuracy of the results that are derived from the investigation.

Criteria for Eligibility

In order to complete this literature evaluation, we looked at published research that discusses the multimodality imaging of patients with COVID-19 pneumonia. This is done to enhance the patient's therapy management and to offer an explanation. This paper's primary goal is to demonstrate the applicability of the issues that have been noted overall.

To be eligible to participate in the study, researchers had to meet the following requirements: 1) English must be used to write the paper. The manuscript must fulfill both of these conditions in order to be considered for publication. 2) A few of the examined studies were released after 2013 but prior to the time frame considered relevant by this systematic review. Editorials, submissions without a DOI, already published review articles, and entries that are nearly exact replicas of journal papers that have already been published are a few examples of research that are prohibited.

Search Strategy

We used "imaging" and "covid 19" as keywords.The search for studies to be included in the systematic review was carried out using the PubMed and SAGEPUB databases by inputting the words: (("image"[All Fields] OR "image s"[All Fields] OR "imaged"[All Fields] OR "imager"[All Fields] OR "imager s"[All Fields] OR "imagers"[All Fields] OR "images"[All Fields] OR "imaging"[All Fields] OR "imaging s"[All Fields] OR "imagings"[All Fields]) AND ("covid 19"[All Fields] OR "covid 19"[MeSH Terms] OR "covid 19 vaccines"[All Fields] OR "covid 19 vaccines"[MeSH Terms] OR "covid 19 serotherapy"[All Fields] OR "covid 19 nucleic acid testing"[All Fields] OR "covid 19 nucleic acid testing"[MeSH Terms] OR "covid 19 serological testing"[All Fields] OR "covid 19 serological testing"[MeSH Terms] OR "covid 19 testing"[All Fields] OR "covid 19 testing"[MeSH Terms] OR "sars cov 2"[All Fields] OR "sars cov 2"[MeSH Terms] OR "severe acute respiratory syndrome coronavirus 2"[All Fields] OR "ncov"[All Fields] OR "2019 ncov"[All Fields] OR (("coronavirus"[MeSH Terms] OR "coronavirus"[All Fields] OR "cov"[All Fields]) AND 2019/11/01:3000/12/31[Date - Publication])) AND ("pneumonia"[MeSH Terms] OR "pneumonia"[All Fields] OR "pneumonias"[All Fields] OR "pneumoniae"[All Fields] OR "pneumoniae s"[All Fields])) AND ((clinicaltrial[Filter]) AND (2014:2024[pdat])) used in searching the literature.

Data retrieval

After reading the abstract and the title of each study, the writers performed an examination to determine whether or not the study satisfied the inclusion criteria. The writers then decided which previous research they wanted to utilise as sources for their article and selected those studies. After looking at a number of different research, which all seemed to point to the same trend, this conclusion was drawn. All submissions need to be written in English and can't have been seen anywhere else.

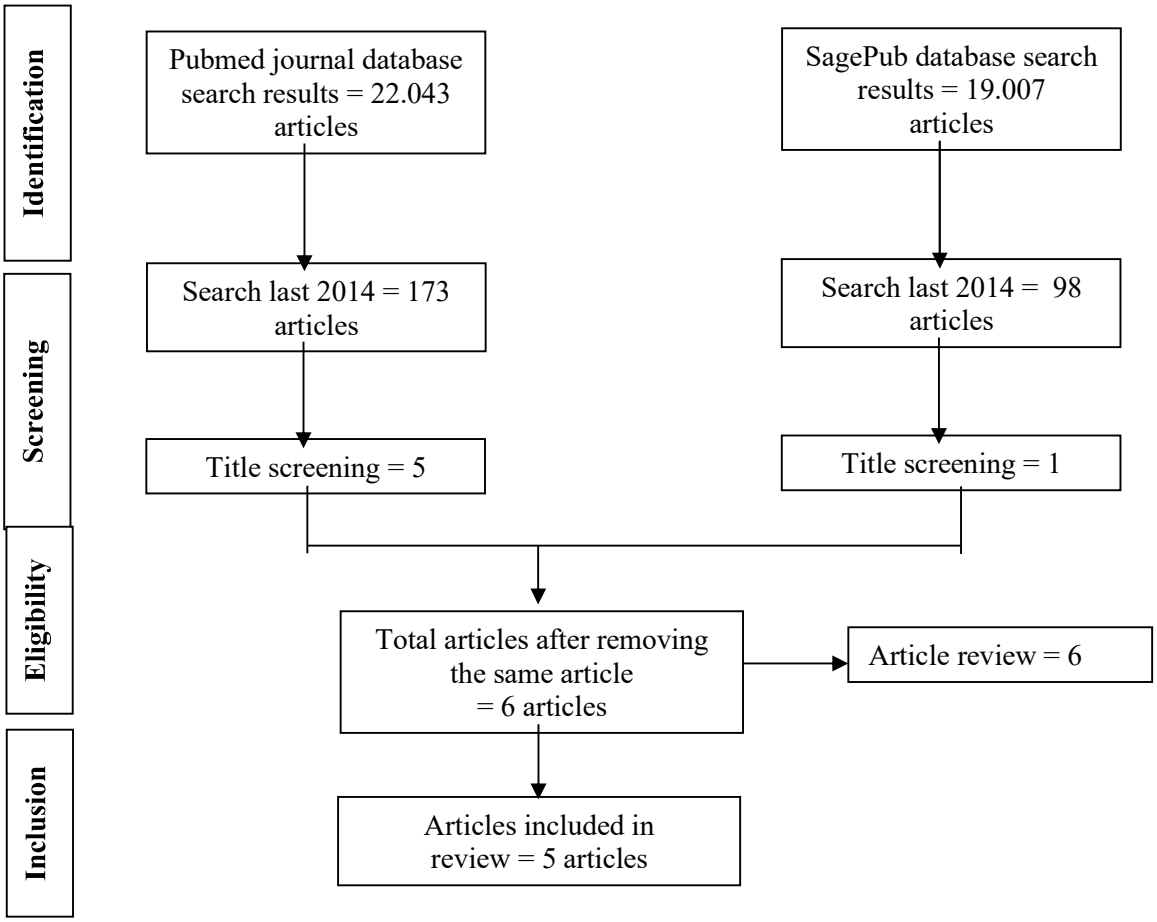

Figure 1. Article search flowchart

Only those papers that were able to satisfy all of the inclusion criteria were taken into consideration for the systematic review. This reduces the number of results to only those that are pertinent to the search. We do not take into consideration the conclusions of any study that does not satisfy our requirements. After this, the findings of the research will be analysed in great detail. The following pieces of information were uncovered as a result of the inquiry that was carried out for the purpose of this study: names, authors, publication dates, location, study activities, and parameters.

Quality Assessment and Data Synthesis

Each author did their own study on the research that was included in the publication's title and abstract before making a decision about which publications to explore further. The next step will be to evaluate all of the articles that are suitable for inclusion in the review because they match the criteria set forth for that purpose in the review. After that, we'll determine which articles to include in the review depending on the findings that we've uncovered. This criteria is utilised in the process of selecting papers for further assessment. in order to simplify the process as much as feasible when selecting papers to evaluate. Which earlier investigations were carried out, and what elements of those studies made it appropriate to include them in the review, are being discussed here.

RESULT

In the PubMed database, the results of our search brought up 22.043 articles, whereas the results of our search on SAGEPUB brought up 19.007 articles. The results of the search conducted for the last year of 2014 yielded a total 173 articles for PubMed and 98 articles for SAGEPUB. In the end, we compiled a total of 6 papers, 5 of which came from PubMed and 1 of which came from SAGEPUB. We included five research that met the criteria.

Wang, et al[7] (2022) showed that for individuals with proven COVID-19 pneumonia, computed tomography (CXR) imaging is useful in monitoring the evolution of the pulmonary lesions. CT is useful for lesion staging and early diagnosis. The pneumonia caused by the novel coronavirus illness 2019 (COVID-19) is still a worry. Findings on chest CT of COVID-19 pneumonia have been documented extensively, however studies on chest X-rays (CXR) are comparatively rare.

Raoufi, et al[8] (2020) showed that clinical results and chest CT severity ratings are comparable across Iranian COVID-19 patients with well-controlled and poorly-controlled diabetes.

Dietz, et al[9] (2021) showed that FDG PET/CT scans of COVID-19 patients clearly show an inflammatory process during what is thought to be the apex of the inflammatory phase. The lungs are usually the site of glucose absorption, which is diverse. [18F]The sensitive and quantitative method of 2-Fluoro-2-deoxy-D-glucose PET/CT (FDG PET/CT) is used to identify inflammatory processes. Increased anaerobic glycolysis in activated inflammatory cells such monocytes, lymphocytes, and granulocytes is linked to glucose absorption.

Table 1. The litelature include in this study

Author	Origin	Method	Sample	Result
Wang et al, 2022[7]	China	Retrospective study	28 patients	About 67.9% (19/28) of the individuals reported abnormal CXR results. Ground-glass opacities (GGO) (100%, 19/19) and consolidation (68.4%, 13/19) were the most frequent symptoms in CXR. 26 out of 28 patients, or 92.9%, showed abnormal CT symptoms. GGO (88.5%, 23/26), consolidation (69.2%, 18/26), reticular opacity (69.2%, 18/26) and nodule (46.2%, 12/26) were the most frequently occurring symptoms on CT. Consolidation was the sole abnormality across CXR and CT that was consistent (κ=0.510). In both CXR and chest CT, the GGO (ICC=0.501) and consolidation (ICC=0.431) values were similar. In fourteen cases, the staging findings were identical; the majority of these cases were in stages I and II. While CT was more advanced than CXR in some patients with mixed findings, primarily in stages III and IV of the illness.
Raoufi et al, 2020[8]	Iran	Retrospective single center study	117 patients	Of all the patients with diabetes, 93 (79.5%) had poorly managed diabetes, and 24 (20.5%) had well-controlled diabetes; the median age of the patients was 66 years (IQR, 55–75 years), and 66 (56.4%) were male. Patients with well-controlled diabetes and those with poorly-controlled diabetes did not vary substantially in their chest CT severity levels (p = 0.33).

				Additionally, there was little difference in the two groups' rates of death and recovery (p = 0.54 and 0.85, respectively).
Dietz et al, 2021[9]	Monaco	Prospective study	13 patients	There were thirteen patients in all. In lungs, the maximum standardized uptake values varied from 4.7 to 16.3. Increased glucose absorption by mediastinal lymph nodes was seen in all individuals. A moderate increase in glucose absorption was seen in three patients (23%) with bone marrow, two patients (15%) with nasopharyngeal, and five patients (38%) with splenic. There was no substantial focal or segmental glucose absorption in any of the patients. With the exception of one patient, no substantial physiological myocardial glucose absorption was seen. Neither the short-term clinical outcome nor the evolution of chest CT showed any association with the PET lung inflammatory state.
Ohno et al, 2022[10]	Japan	Randomized study	18 patients	Thirty-two COVID-19 participants who had their first chest CT scan prior to inclusion in the trial were assessed between March and May of 2020. A total of eighteen patients were randomly assigned to begin favipiravir on day one (early treatment group) or day six (late treatment group) of the research. Stepwise regression analysis revealed that both % GGO and % consolidation had significant relationships with time until CT ($p < 0.05$), and both indices were significant descriptors for time until CT ($p < 0.05$). The accuracy of the combined quantitative technique (87.5%) was considerably greater than the CT disease severity score (62.5%, $p = 0.008$) when all patients were separated into groups based on the time interval till CT scan: 4 days or more.
Bercean et al, 2023[11]	Romania	Randomized clinical study	109 patients	Radiologists overestimated the amount of lung involvement by $10.23 \pm 4.65\%$ and $15.8 \pm 6.6\%$, respectively, according to a preliminary poll

				of 40 radiologists and a retrospective examination of CT data from 109 patients from two institutions. Artificial intelligence (AI) decision assistance decreased the absolute overestimation error ($P < 0.001$) in the ensuing randomised controlled trial from $9.5\% \pm 6.6$ (No-AI analysis arm, n = 38) to $1.0\% \pm 5.2$ (AI analysis arm, n = 38). These findings point to a radiological human perception bias that affects the quantitative analysis of COVID-19 on CT in a way that is clinically significant. It was demonstrated that the objectivity of AI was a useful addition in lowering the subjectivity of the radiologist, resulting in a tenfold decrease in overestimation.
Landini et al, 2021[12]	Italy	Retrospective study	274 patients	A total of 274 individuals (146 with COVID-19 and 128 without) had their CR assessed. Four characteristics made up the most accurate COVID-19 pneumonia pattern: no pleural effusion (Expß=0.4, P=0.009), peripheral distribution of the predominant (Expß=2.3, P=0.013), bilateral changes (Expß=2.8, P=0.002), and unblurred perihilar vascular contour (Expß=0.3, P=0.002). In comparison to BSTI criteria, which showed 51%, 77%, and 63%, respectively, the pattern demonstrated 49% sensitivity, 81% specificity, and 64% accuracy.

Ohno, et al[10] (2022) showed that when estimating how long it will take for COVID-19 patients to receive CT for favipiravir therapy, machine learning-based CT texture analysis is just as effective as CT disease severity score. Furthermore, favipiravir treatment's impact on COVID-19 patients may be more accurately predicted by ML-based CT texture analysis than by CT disease severity score.

Bercean, et al[11] (2023) showed that the technique of quantifying the lung involvement in COVID-19 on CT images is perception-sensitive and subject to cognitive overestimation bias. Despite the fact that the marker is widely used, it has been demonstrated that it can be controlled using an AI decision support system, therefore this is crucial. This highlights the advantages of combining human and artificial intelligence and emphasizes the necessity for more research on radiology's capacity to adapt to fast changes in methodology and technology.

Landini, et al[12] (2021) showed that the most accurate COVID-19 pneumonia pattern is determined by bilaterality, peripheral distribution of the major lung change, absence of pleural effusion, and unblurred perihilar vascular contour. The BSTI criteria's suggested lower field engagement was not a noteworthy finding. The specificity of the BSTI criterion is lower.

DISCUSSION

Acute Respiratory Syndrome Severe As COVID-19 (coronavirus disease 2019), the coronavirus 2 (SARS-CoV-2) infection is causing more than 696.000 fatalities globally to date (August 6, 2020). This is an epoch-making global healthcare disaster. While COVID-19 can manifest as a multiorgan illness, the lung is the target organ most frequently afflicted. Clinical signs might range from fever, dry cough, myalgia, and exhaustion, which are typical flu-like symptoms, to hypo- or asthenia and ageusia. The RT-PCR test's result availability delay is another cause for concern. In fact, based on the experience, the majority of patients who arrived at the emergency room suspecting they had COVID-19 pneumonia had their initial radiological examination performed prior to learning the outcome of the swab test.[1,13,14]

The imaging tests that are typically used to diagnose COVID-19 pneumonia include CXR and CT. In this clinical context, transportable CXR devices are used in a designated, isolated room to minimize the danger of infection spreading. CXR is simple to use and is often conducted in the supine position and in the antero-posterior (AP) projection. Using small sections (<1.5 mm) and a high-spatial resolution kernel to increase lung parenchymal anatomical features, chest CT is conducted using the high-resolution (HRCT) method, typically without the need for contrast media injection. Nonetheless, data point to a propensity for thrombotic and thromboembolic illness in these individuals, with pulmonary embolism (PE) recognized as a COVID-19 syndrome epiphenomenon. In order to rule out PE, contrast medium injection must be administered in the proper clinical environment.[15,16]

Imaging, particularly CT, can identify potential alternative diagnoses (pulmonary oedema, alveolar hemorrhage, or other types of lung infections) that could account for the patient's respiratory symptoms in addition to identifying COVID-19 pneumonia characteristics. The latest Fleischner Society consensus statement further emphasizes the significance of CT as a rule-out, especially for patients presenting with moderate-to-severe symptoms with a negative or continuing RT-PCR test.[17]

The use of chest CT is especially beneficial for individuals who have known pre-existing lung illnesses, according to the WHO recommendation guide. A categorical assessment scheme, the COVID-19 Reporting and Data System (CO-RADS), has been proposed to standardize the level of suspicion of COVID-19 pneumonia on CT scans. The levels range from very low (CO-RADS category 1) to very high suspicion (CO-RADS category 5), with a CO-RADS 6 category reserved for RT-PCR proven cases. In COVID-19 pneumonia, imaging is especially important for patient classification and prognostic evaluation. Recently, many CXR scoring systems have been created with intriguing outcomes to address these demands in clinical practice.[18]

There is certainly no doubting the value of chest imaging in evaluating the course of a disease. CXR is crucial for directing clinical therapy in hospitalized patients because it permits a sufficient assessment of the results' progression while preventing needless radiation exposures. This is particularly true for individuals who are in serious condition or when their symptoms start to improve. HRCT is the preferred method for a late follow-up, especially for evaluating any chronic or fibrotic lung abnormalities. Finally, imaging plays a critical role in the timely identification of problems such empyema, superimposed bacterial lung infections, and barotrauma.

CONCLUSION

In summary, owing to the SARS-CoV-2 pandemic, it is critical to understand the typical and atypical imaging features of COVID-19 pneumonia as well as how they change over time on CXR and HRCT. When evaluating hospitalized and critically sick patients in a serial fashion, as well as in places with high levels of contagion, computed tomography (CXR) may be the initial imaging modality employed. However, HRCT has a poor specificity in regions where the disease is not as common. For this reason, it ought to be the preferred modality for evaluating differential diagnosis between infectious and non-infectious lung ailments as well as when treating individuals who already have a lung ailment. Radiologists are more confident in their ability to diagnose diseases at the time of initial presentation, as well as in identifying potential problems and differential diagnosis, when they are aware of the link between imaging findings and underlying pathophysiology.

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