

DIAGNOSTIC IMAGING OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE: A TEN YEARS SYSTEMATIC REVIEW

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ABSTRACT

Background: Exacerbations of chronic obstructive pulmonary disease (COPD) impose a great burden on patients' quality of life and healthcare systems. In addition to causing significant increases in mortality and disease progression, exacerbations of COPD amount to \$18 billion in direct costs annually, as well as further spending associated with care and losses in productivity. Newer modalities such as OCT and MRI have distinct advantages to CT in such areas as image resolution and functional assessment of lung tissue.

The aim: The aim of this study to show about diagnostic imaging of chronic obstructive pulmonary disease.

Methods: 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. This search approach, publications that came out between 2014 and 2024 were taken into account. Several different online reference sources, like Pubmed, SagePub, and Google Scholar 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 get 100 articles, whereas the results of our search on SagePub get 1608 articles, on Google Scholar 3870 articles. Records remove before screening are 4887, so we get 691 articles for screening. After we screened based on record exclude, we compiled a total of 10 papers. We included five research that met the criteria.

Conclusion: Imaging and image analysis offers new insight into pulmonary disease processes that were previously available only on tissue necropsy. Current techniques can offer detailed measures of lung structure and with newer modalities previously immeasurable things like regional lung function. Imaging in the context of clinical investigation may offer the ability to define more homogeneous subsets of subjects with COPD and to potentially provide an intermediate biomarker of disease progression in lieu of a declining FEV.

Keyword: Chronic obstructive pulmonary disease (COPD), Imaging, diagnostic, CT, MRI.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a pathologic condition of the lung characterized by emphysematous destruction of the lung parenchyma and remodeling of the small airways. The admixture of these two processes leads to what is clinically observed as expiratory airflow obstruction that is not completely reversible with the use of inhaled bronchodilating medications. Despite ongoing refinements in the spirometric classification of disease, marked heterogeneity still exists in both subject symptoms and response to therapeutic intervention. This inconsistent association between lung function and disease manifestations has led to increasing interest in image based methods for the diagnosis and classification of COPD.^{1,2}

The diagnosis of chronic obstructive pulmonary disease (COPD) has traditionally relied on spirometry. This reliance on spirometry for diagnosis and severity assessment has led to modest advances in our understanding of underlying pathophysiology. COPD is increasingly recognized as a complex heterogeneous disease, and recent advances in computed tomography (CT) have enabled extensive phenotyping of COPD by allowing morphologic characterization of parenchymal and airways disease. CT enables visualization of structural derangements and hence anatomic localization of disease, in contrast to spirometry, which is a more global measure. Indeed, substantial disagreement can exist between spirometric assessment of airflow obstruction and quantitation of structural lung disease. Visual analysis can provide semiquantitative estimates of overall degree of emphysema, as well as of emphysema subtypes. In combination with qualitative estimates of airway disease, visual analysis has enabled phenotyping of COPD into emphysema and airways-predominant disease, with implications for respiratory morbidity and disease outcomes.^{3,4}

METHODS

Protocol

By following the rules provided by Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, the author of this study made certain that it was up to par with the requirements. This is done to ensure that the conclusions drawn from the inquiry are accurate.

Criteria for Eligibility

For the purpose of this literature review, we compare and contrast diagnostic imaging of chronic obstructive pulmonary disease. It is possible to accomplish this by researching or investigating diagnostic imaging of chronic obstructive pulmonary disease. As the primary purpose of this piece of writing, demonstrating the relevance of the difficulties that have been identified will take place throughout its entirety.

In order for researchers to take part in the study, it was necessary for them to fulfil the following requirements: 1) The paper needs to be written in English, and it needs to determine about diagnostic imaging of chronic obstructive pulmonary disease. In order for the manuscript to be considered for publication, it needs to meet both of these requirements. 2) The studied papers include several that were published after 2014, but before the time period that this systematic review deems to be relevant. Examples of studies that are not permitted include editorials, submissions that do not have a DOI, review articles that have already been published, and entries that are essentially identical to journal papers that have already been published.

Search Strategy

We used " diagnostic imaging of chronic obstructive pulmonary disease." 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: ("Chronic obstructive pulmonary disease "[MeSH Subheading] OR "COPD"[All Fields] OR "diagnosis" [All Fields]) AND ("diagnosed"[All Fields] OR " diagnostic "[All Fields]) AND ("Diagnosed of chronic obstructive pulmonary disease "[All Fields]) OR ("Diagnostic imaging" [All Fields])) 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 cannot 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

From the PubMed database, the results of our search get 100 articles, whereas the results of our search on SagePub get 1608 articles, on Google Scholar 3870 articles. Records removed before screening are 4887, so we get 691 articles for

screening. After we screened based on record exclude, we compiled a total of 10 papers. We included five research that met the criteria.

Wainwright, M (2018)⁵ showed Medical technology and images impact patients'embodiment. Understanding this is important for rehabilitation practitioners who work in a challenging space created by potentially conflicting medical narratives: on the one hand, chronic obstructive pulmonary disease is incurable permanent damage, and on the other, improvement is possible through rehabilitation. Drawing could be integrated into pulmonary rehabilitation and may help identify perceptions of the body that could hinder the rehabilitation process.

Macneil, JL et al (2020)⁶ showed Multiparametric response maps revealed two abnormal structure-function results related to emphysema and small airways disease, both of which were unexpectedly present in ex-smokers with normal spirometry and CT findings.

Table 1. The literature include in this study

Author	Origin	Method	Sample Size	Result
Wainwright, M., 2018 ⁵	South Africa	Employing graphic elicitation, in one of multiple ethnographic interviews, participants were asked to draw their lungs: "If we could look inside your chest now, what would we see?" Lung drawings and accompanying narratives and fieldnotes from 14 participants were analyzed for themes and patterns.	14	The theme of "imaging/imagining" emerged and three distinct patterns within this theme were identified: the microscope perspective, the X-ray perspective and the reduced pulmonary capacity perspective. These patterns demonstrate how embodiment can be shaped by an integration and reinterpretation of the medical images that form part of everyday clinic visits and pulmonary rehabilitation.
Macneil, JL et al., 2020 ⁶	Canada	prospective study	175	A total of 175 ex-smokers (mean age, 69 years ± 9 [standard deviation], 108 men) with or without COPD were evaluated. Ex-smokers without COPD had a larger fraction of normal mPRM voxels (60% vs 37%, 20%, and 7% for GOLD I, II, and III/IV disease, respectively; all $P \leq .001$) and a smaller fraction of abnormal voxels, including small airways disease (normal CT, not ventilated: 5% vs 6% [not significant], 11%, and 19% [$P \leq .001$ for both] for GOLD I, II, and III/IV disease, respectively) and mild emphysema (normal CT, abnormal apparent diffusion coefficient [ADC]: 33% vs 54%, 56%, and 54% for GOLD I, II, and III/IV disease respectively; all $P \leq .001$). Normal mPRM measurements were positively correlated with

				<p>forced expiratory volume in 1 second (FEV₁) ($r = 0.65, P < .001$), the FEV₁-to-forced vital capacity ratio ($r = 0.81, P < .001$), and diffusing capacity ($r = 0.75, P < .001$) and were negatively correlated with worse quality of life ($r = -0.48, P < .001$). Abnormal mPRM measurements of small airways disease (normal CT, not ventilated) and mild emphysema (normal CT, abnormal ADC) were negatively correlated with FEV₁ ($r = -0.65$ and -0.42, respectively; $P < .001$) and diffusing capacity ($r = -0.53$ and -0.60, respectively; $P < .001$) and were positively correlated with worse quality of life ($r = 0.45$ and $r = 0.33$, respectively; $P < .001$), both of which were present in ex-smokers without COPD.</p>
<p>Willer, K et al., 2021⁷</p>	<p>Germany</p>	<p>In this diagnostic accuracy study, we designed and built a novel dark-field chest x-ray system (Technical University of Munich, Munich, Germany)—which is also capable of simultaneously acquiring a conventional thorax radiograph (7 s, 0.035 mSv effective dose).</p>	<p>77</p>	<p>Between October, 2018 and December, 2019 we enrolled 77 patients. Compared with CT-based parameters (quantitative emphysema $\rho = -0.27$, $p = 0.089$ and visual emphysema $\rho = -0.45$, $p = 0.0028$), the dark-field signal ($\rho = 0.62$, $p < 0.0001$) yields a stronger correlation with lung diffusion capacity in the evaluated cohort. Emphysema assessment based on dark-field chest x-ray features yields consistent conclusions with findings from visual CT image interpretation and shows improved diagnostic performance than conventional clinical tests characterising emphysema. Pair-wise comparison of corresponding test parameters between adjacent visual emphysema severity groups (CT-based, reference standard) showed higher effect sizes. The mean effect size over the group comparisons (absent-trace, trace-mild, mild-moderate, and moderate-confluent or advanced destructive visual emphysema grades) for the COPD assessment test score is 0.21, for forced expiratory volume in 1 s (FEV₁)/functional vital capacity is 0.25, for FEV₁% of predicted is 0.23, for residual</p>

				<p>volume % of predicted is 0.24, for CT emphysema index is 0.35, for dark-field signal homogeneity within lungs is 0.38, for dark-field signal texture within lungs is 0.38, and for dark-field-based emphysema severity is 0.42.</p>
<p>Srinivas, RK et al., 2023⁸</p>	<p>India</p>	<p>prospective observational single-center study</p>	<p>60</p>	<p>OE-MRI was performed by administering oxygen at 12 L/min for 4 min to look for ventilation defects. DCE-MRI was performed by injecting intravenous gadolinium contrast, and perfusion abnormalities were detected by subtracting the non-enhanced areas from the first pass perfusion contrast images. A total of 87% of the subjects demonstrated ventilation and perfusion abnormalities on MRI independently. The lobe-wise distribution of ventilation and perfusion abnormalities correlated well with each other and was statistically significant in all lobes ($p < 0.05$). The severity of ventilation-perfusion defects also correlated well with clinical severity, as their median value (calculated using a Likert rating scale) was significantly lower in patients in the Global initiative for chronic Obstructive Lung Disease (GOLD) I/II group (3.25) compared to the GOLD III/IV group (7.25). OE- and DCE-MRI provide functional information about ventilation-perfusion defects and their regional distribution, which correlates well with clinical severity in patients with COPD.</p>
<p>Hwang, HJ et al., 2020⁹</p>	<p>South Korea</p>	<p>Prospective study</p>	<p>67</p>	<p>Most patients with ACOS showed the peripheral wedge/diffuse defect (n = 14, 66.7%), whereas patients with COPD commonly showed the diffuse heterogeneous defect and lobar/segmental/subsegmental defect (n = 21, 45.7% and n = 20, 43.5%, respectively). The prevalence of ventilation defect patterns showed significant intergroup differences ($p < 0.001$). The quantified ventilation values in the peripheral lung areas were significantly lower in patients</p>

				with ACOS than in patients with COPD ($p = 0.045$). The quantified Pi10 was significantly higher in patients with ACOS than in patients with COPD ($p = 0.041$); however, EI was not significantly different between the two groups.
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Willer, K et al (2021)⁷ showed X-ray dark-field chest imaging allows the diagnosis of pulmonary emphysema in patients with COPD because this technique provides relevant information representing the structural condition of lung parenchyma. This technique might offer a low radiation dose alternative to CT in COPD and potentially other lung disorders.

Srinivas, RK et al (2023)⁸ showed oxygen-enhanced and dynamic contrast-enhanced MRI provides morphological and functional information about ventilation and perfusion defects in chronic obstructive pulmonary disease patients and correlates well with clinical severity.

Hwang, HJ et al (2020)⁹ showed the ventilation abnormalities on the visual and quantitative assessments of xenon-ventilation DECT differed between patients with ACOS and patients with COPD. Xenon-ventilation DECT may demonstrate the different physiologic changes of pulmonary ventilation in patients with ACOS and COPD.

DISCUSSION

Chronic obstructive pulmonary disease (COPD) remains a leading cause of mortality worldwide. Clinical diagnosis of COPD has classically relied upon detecting irreversible airflow obstruction on pulmonary function testing (PFT) as a global assessment of pulmonary physiology. The natural history of COPD is characterized by an irreversibly progressive decline in lung function, with the pathophysiology resulting in airway obstruction characterized by either the loss alveolar gas exchange units and elasticity or the development of muco-fibrotic airway remodeling. These paradigms have served as the basis for the two classic COPD phenotypes: emphysema and chronic bronchitis. However, this basic dogma has been challenged in recent years as varying degrees of co-existing emphysema, chronic bronchitis, and potentially significant vascular pathologies have been appreciated in patients with COPD.^{10,11}

Even though not endorsed by GOLD for diagnosis, in clinical practice patients with COPD are imaged frequently, for a variety of indications, which include clinical exacerbations, pulmonary infections and suspected malignancy. On most clinical imaging, the signs of COPD are described simply as present or absent. Some practices will provide a subjective assessment of severity, using categories such as mild, moderate or severe. Obviously, there is substantial variability of what these terms really mean, giving absence of standardization and the highly diverse background of physicians providing imaging interpretation. In an attempt to standardize semi-quantitative clinical assessment of COPD and harmonize it with published data on quantitative computed tomography (QCT) phenotypes, a statement of the Fleischner Society proposed a visual CT based classification system comprised by five different emphysema predominant subtypes and two distinct airway predominant subtypes, and identified this proposal as a work in progress to drive future research, including outcomes of distinct CT phenotypes.^{12,13}

CT-based investigation has also demonstrated that the lung manifests divergent responses to noxious insults such as chronic tobacco smoke exposure. Smokers may appear resilient to the injurious effects of tobacco smoke or may develop emphysema and even pulmonary fibrosis. Recent investigation suggests approximately 6% to 8% of smokers over the age of 50 have some degree of interstitial remodeling of the lung parenchyma. These processes have collectively been termed interstitial lung abnormalities (ILAs) and have been shown to have similar genetic associations as advanced pulmonary fibrosis. The presence of ILA is independently associated with all-cause and respiratory-specific mortality in population-based studies. Extensive work is ongoing to determine which subset of these ILAs progress to classic interstitial lung disease and potentially when to initiate antifibrotic therapy.^{14,15}

On MRI, alveolar destruction is assessed by hyperpolarized gas imaging. ADC obtained from diffusion-weighted MRI of inhaled hyperpolarized helium 3 (³He) or xenon 129 (¹²⁹Xe) provide a relative measure of alveolar size. ¹²⁹Xe is more widely available than ³He, and can also directly evaluate gas exchange. A recent study of 10 healthy volunteers, 16 with mild or moderate COPD, and 10 with severe COPD showed that ¹²⁹Xe provided very similar ADC results to ³He, with progressively increasing ADC in subjects with increasing severity of COPD. ADC values correlated more strongly than %LAA.₉₅₀ with lung diffusing capacity (Spearman rank correlation coefficient 0.80 for ¹²⁹Xe compared with -0.61 for %LAA.₉₅₀).¹⁶

CONCLUSION

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