

The Role of Artificial Intelligence and Technology in Lung Disease Detection

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Abstract

Over the past few years, the increasing development of technologies are proving to be extremely beneficial to the healthcare community worldwide. Lung cancer and Chronic Obstructive Pulmonary Diseases such as Emphysema and Chronic Bronchitis have seen recent changes in industry with the introduction of Artificial Intelligence and Machine learning. There are a variety of current technologies that exist in the detection and monitoring of lung diseases, as well as future advancements that would potentially create a pathway in the qualitative interpretation of lung cancer imaging by expert clinicians. This article will explore a large number of these technologies that have the potential to aid healthcare worldwide and decrease the number of premature deaths from lung diseases.

Keywords: *Artificial Intelligence; Lung Disease; Detection*

Introduction-lung physiology

Lungs are major organs of the respiratory system situated in the thoracic cavity and the right and left part are separated by a mediastinum. The main function of the lungs is to perform gas exchange. Each lung is enclosed within a pleural sac so whilst breathing takes place it allows the inner and outer walls to slide over each other. This sac also divides each lung into sections called lobes. Lungs are composed of lobes, two on the left: the superior and inferior lobes and three on the right: the superior, middle and inferior lobes. Lobes are separated by fissures and are divided into various bronchopulmonary segments. Each segment receives blood from its own artery and is supplied with air from its own tertiary bronchus.

A problem in any part of the entire and complex airway can result in a disorder. A respiratory disorder may be momentary or chronic and a few types may lead to lung diseases. Lung disease can be classified in a number of ways such as diseases affecting the airways, air sacs (Alveoli), Interstitium, Blood Vessels and Pleura. Diseases that affect airways include: Asthma, Chronic Obstructive Pulmonary Disease (COPD) and Emphysema. Some diseases of the lungs typically affect one or more bronchopulmonary segments and in some cases, the diseased segments can be surgically removed with little influence on neighbouring segments.

Artificial intelligence (AI) is a term which refers to techniques that perform tasks that mimic human cognitive functions and intelligence. As a branch of AI, Machine Learning (ML) enables extraction of meaningful patterns from images, providing systems the ability to automatically learn and improve from experience without explicit programming [1]. In the intervening years, computer-aided detection/diagnosis (CADe) underpinned by machine-learning techniques have become a leading research subject in radiology with many applications such as detection and distinction of benign and malignant pulmonary nodules, temporal subtraction for assessment of interval changes between scans, quantifying emphysema and detection of interstitial lung disease [2]. The primary focus for the CADe developers

have been to develop algorithms that improve reporter accuracy and provide computer output that acts as a “second opinion” to the reporting radiologists; however, despite a number of studies showing that CADe help radiologists to improve their diagnostic accuracy, the technology has failed to achieve clinical acceptance [3].

Lung infections and current technologies

Lung cancer

For both genders, lung cancer is among the most deadly cancers and exceeds the death rate of other common cancers such as breast, pancreatic together [4]. Medical imaging and Artificial Intelligence play a crucial role in the 3 stages - detection, characterization and monitoring of tumors in lung cancer through distinguishing between malignant and benign nodules. When these stages are early stages, they are frequently curable and thus can drastically improve patient outcomes, minimize overtreatment and even save lives. Detection, popularly known as Computer Aided Detection (CADe) refers to the localization of objects of interest in radiographs. CADe is utilised to identify missed cancers in low-dose CT screening, detect brain metastases in MRIs to improve radiology interpretation time while maintaining high detection sensitivity, locate micro calcification clusters in screening mammography as an indicator of early carcinoma and more generally has improved radiologist sensitivity for detecting can abnormalities [5].

Detection of small pulmonary nodules is fundamental for early diagnosis of lung cancer. Substantial variability has been reported in the sensitivity of radiologists in detecting these nodules and this be impacted by a variety of characteristics such as size, shape, location, density, and their relationship to the adjacent structures [6]. In the context of pulmonary nodules, volume doubling time is a key indicator of malignancy. In addition, alteration in the morphology of nodules, such as cavitation, speculation and density change, also help distinguish between benign and malignant nodules.

Characterization is classified as the “segmentation, diagnosis and staging of tumors”. The level of abnormality is termed as segmentation. This can range right from basic 2-D measurements of the maximal in-plane tumor diameter to volumetric segmentations where the tumor as a whole along with its possible surrounding tissues are considered.

In current clinical practice, even though segmentation which is manually traced is repeatedly utilised as the basis for judging the accuracy of automated segmentation algorithms, it often overlooks the subclinical disease and limits analysis to human bias [7]. An increase in efficiency, quality of tumour measurements and reproducibility can be seen using AI in automated segmentation.

Finally, AI can play increasing roles in monitoring changes in a tumor over time, either in natural history or in response to treatment. Traditional temporal monitoring of tumors often has been limited to predefined metrics including tumor longest diameter measured through the established Response Evaluation Criteria in Solid Tumors (RECIST) and World Health Organization (WHO) criteria for estimating tumor burden and determining treatment response [8].

Current advances in medical technology and artificial intelligence aid mankind in facing challenges from cancer detection and monitoring to treatment. Complement clinical decision making is possible as AI is more efficient than humans at quantifying information from images and recognizing complex image patterns in images. This allows advancements purely qualitative and subjective interpretations to reproducible and quantifiable ones. AI could also pave path for the accumulation of various data streams into powerful integrated diagnostic systems spanning pathology, radiographic images, electronic health records, genomics and social networks [9].

Chronic obstructive pulmonary disease (Emphysema and chronic bronchitis)

Chronic Obstructive Pulmonary Disease (COPD) is an umbrella term used to describe progressive lung diseases such as emphysema and chronic bronchitis [10]. Increased numbers of macrophages and activated polymorphonuclear leukocytes discharge an enzymes

responsible for degradation called elastases. Destruction of the lungs is a result of the inability to successfully counter the release of elastases. Consequently, the respiratory surface area where gas exchange takes place decreases in size. Moreover, breathing problems arise as the increased airflow resistance within the airways cause air trapping in the lung and lung hyperinflation [11]. Emphysema is often caused from long-term smoking where the lungs produce an excessive amount of mucus and the alveoli become damaged. It becomes difficult to breathe and get enough oxygen into the blood [12]. In chronic bronchitis, another common disease caused by smoking, the membranes lining the larger bronchial tubes become inflamed and an excessive amount of mucus is produced. The person develops a cough to get rid of the mucus. Both diseases are characterized by increasing breathlessness and although incurable, with the right diagnosis and therapeutic approach, there are many things you can do to manage COPD by slowing the progression of the disease to breathe better. Although healthcare is improving, there are many existing issues several current issues related to the diagnosis and monitoring of COPD. Some of these problems can be resolved with the aid of existing and advancing technologies.

Various existing technologies include: wearable technologies, biomarkers, telehealth technologies, questionnaires, imaging technologies, spirometers and vital sign monitors [13].

Using devices worn across the chest and wrist, current wearable technologies monitor steady COPD factors such as respiratory rate, wheeze, blood oxygenation and temperature are already available. Some current biomarkers served as a method to identify patients with early COPD at risk of progression. Fourier transform infrared spectroscopic monitoring used sputum to rapidly differentiate COPD from other respiratory conditions and determine the risk of an imminent exacerbation. Telehealth is a popular area of development in technologies for chronic diseases and represented a large proportion of all technologies identified. From a distance they provide health information, clinical care, or health education. However, a drawback exists as a healthcare professionals required to look at the data. Spirometer technologies prevalent today are used to monitor COPD and its primary benefits are identifying individuals who might benefit from pharmacologic treatment as means of improving exacerbations [14]. These include adults with symptomatic, severe to very severe airflow obstruction. Spirometry technologies provide independent prognostic values for predicting respiratory and on a whole, morbidity and mortality.

Future advancements in technology

AI promises to make great strides in the qualitative interpretation of lung cancer imaging by expert clinicians, including volumetric delineation of tumors over time, extrapolation of the tumor genotype and biological course from its radiographic phenotype, prediction of clinical outcome and assessment of the impact of disease and treatment on adjacent organs. Moving forward, deep learning offers the possibility of doing away with nodule segmentation altogether as the CNN approach can handle segmentation in an implicit way within the algorithm [15].

It is likely that future analysis of cancer lesions will not demand a separate segmentation step as the whole-body imaging data could possibly be evaluated directly by AI algorithms. Moreover, with the increasing development of computing speed and the expansion in efficiency of Artificial Intelligent algorithms, A whole-body approach also can allow an analysis of organ structures that may be pathological and much beyond the range of human vision [16].

COPD has various technologies in place, but a few underdeveloped ones have large future scope. Novel biomarkers offered a potential future alternative approach to early diagnosis and the differentiation from other respiratory diseases, including several based on sputum or saliva samples with results available at the point of care [13].

Several new technologies allow self-monitoring COPD devices at home with remote access by clinicians, though the feasibility of multiple clinicians interpreting large volumes of recorded data was questioned. An example is the imaging techniques as they could play an important part in future clinical studies. They aid in visualizing drug-related changes in the bronchopulmonary system faster and more

accurately than was previously possible. The endpoints used in clinical studies today, such as lung function parameters, only show slow changes, thus necessitating long-term studies to show drug effects [17]. Showing the changes through imaging techniques might achieve the same purpose more quickly and more quantifiably. In the diagnosis of lung disease, the future, more even than today, belongs to imaging-both clinically and in research. To make the best use of this, closer collaboration between clinical physicians and radiologists will be important.

Conclusion

As presented above, there are various innovative technologies currently in use that scientifically aid healthcare for lungs worldwide. The most promising technologies have the potential to improve the early diagnosis of lung diseases, namely lung cancer and Chronic Obstruction Pulmonary Diseases. They have facilitated self-monitoring for patients and determined the source of acute exacerbations. Many technologies offered the potential to facilitate patient self-monitoring, including vital sign monitors (including wearable technologies), telehealth systems, smartphone-based spirometers and biomarkers, with a home-use sputum test potentially allowing advance warning of an acute exacerbation.

While a large number of these technologies have the potential to aid healthcare worldwide and decrease the number of premature deaths from diseases, a few technologies such as telehealth and wearable technologies are often considered less promising and impractical to future development and aid in new research [18-22]. This review enables the focus of future research funding and health technology assessment activities to be appropriately targeted, thereby facilitating the adoption of technologies with the potential to make a significant impact on healthcare and the quality of patients' lives.

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