EC NURSING AND HEALTHCARE
Mini Review

Review: Augmented Interpretable Intelligence in the Diagnostic Evaluation of COVID-19

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Abstract

COVID-19, caused by a novel member of the coronavirus family, is a respiratory disease that rapidly reached pandemic proportions with high morbidity and mortality. It has had a dramatic impact on society and world economies in only a few months. COVID-19 presents numerous challenges to all aspects of healthcare, including reliable methods for diagnosis, treatment, and prevention. In a time of resource scarcity, the ability to accurately and quickly sort affected from non-affected patients and to sort the infected into risk-adjusted groups during triaging, a vital task for maintaining health resources for those most in need of them, is of the utmost importance.

Artificial intelligence (AI) represents a potential solution to this problem. Machine learning (ML) is a subset of AI that employs deep learning with neural network algorithms. It can recognize patterns and achieve complex computational tasks often far quicker and with increased precision than humans. We describe a number of various organ systems affected by COVID-19, and the potential applicability of using AI to aid in the interpretation and augment diagnosis of COVID-19 in the context of radiological examinations. In this review, we discuss a myriad of pulmonary, neurologic, and gastrointestinal manifestations of COVID-19, and examine potential applicability of artificial intelligence as it relates to image interpretation of these organ systems.

Keywords: *COVID-19; Coronavirus; AI; Diagnosis; Radiology; Deep Learning*

Introduction

AI falls under a branch of computer science in which machines perform human level intelligent tasks. Machine learning (ML) is a subset of Artificial Intelligence (AI) and is achieved by using mathematical models to compute sample data sets. Utilizing deep learning, a subset of ML, neural networks algorithms are utilized to identify patterns of disease and may aid the diagnostic radiologist in interpretation of COVID-19 and its associated imaging manifestations.

This review article serves to review the radiological findings reported in COVID, and the potential applicability of AI in this context. A myriad of imaging manifestations have been reported in the setting of COVID-19, ranging from stroke to extensive lung injury, to thromboembolic disease.

The ability of AI to both screen and diagnose emerging health crises such as COVID-19 has the potential to dramatically change how we approach medical care in the future. The utility of AI has already been demonstrated in the screening of additional infectious etiologies, such as tuberculosis, particularly in resource restricted areas [1].

Emerging diseases such as COVID-19 present extensive challenges to the healthcare sector. As evidenced with COVID-19, despite a concerted effort, there may be significant lag from the time of first recognition of an emerging pathogen to the development of methods for reliable diagnosis. Moreover, challenges may abound with respect to supply chains as it relates to personal protective equipment (PPE), nasopharyngeal swabs and other testing agents, which may further delay the diagnosis.

The gold standard for diagnosis of COVID-19 is by reverse transcriptase polymerase chain reaction (RT-PCR) technologies, but early RT-PCR testing produced less than optimal results [2-4]. In the setting of emerging diseases such COVID-19 the ability to scale testing kits efficiently produces additional challenges. Therefore, imaging remains a vital and scalable tool in the diagnostic evaluation of COVID-19. This article serves to review the areas of applicability and advances in deep learning (DL) and convolutional neural networks (CNN) in pattern recognition in serving as a valuable rapidly scalable tool in aiding the diagnostic radiologist [5].

Neurologic

Wide-ranging neurologic manifestations have been described in multiple COVID-19 case reports. Importantly there appears to be an increased stroke incidence and worse post-stroke complications in severely affected COVID-19 patients [6-10]. Cases of patients younger than 50 years of age presenting with large vessel occlusion have also been described and suggest a possible causal relationship [8]. Hence, utilization of AI tools to aid the radiologist in the detection of large vessel occlusion will be valuable tool in helping the radiologist reduce time to ischemic vessel identification and subsequent treatment time.

Quantification of infarcted core volume and mismatch volume to highlight areas of ischemic penumbra with color coded maps could be critical in assisting the neurology and interventional neuroradiology teams in deciding to pursue or stay endovascular therapy. With the potential for stroke to be the initial presentation of COVID-19, AI tools may be deployed early in the patients' clinical course in assisting the radiologist of quantitative assessment of stroke parameters [8].

There have also been reported cases of COVID-19 associated extra-axial intracranial hemorrhage as well as a case of hemorrhagic necrotizing encephalopathy [11-13]. It is difficult to say at this point if there is a direct causative relationship between SARS-CoV-2 and intracranial hemorrhage by an as of yet unexplained mechanism or if reported hemorrhages are a result of underlying comorbidities exacerbated by infection. Regardless, rapid identification of intracranial hemorrhage is critical to neurosurgical evaluation and treatment and many AI tools have been FDA cleared for the initial triaging of hemorrhage. These same tools may also serve as a frontline tool in atypical presentations of COVID-19.

Pulmonary

The first potential of augmented AI in the imaging workflow lies in the examination of CXRs in patients with COVID-19. This serves as a front line tool, often used conjunctively with testing. CXR findings described in COVID-19 patients include normal CXR, consolidation, and hazy increased opacities [14-18]. The majority of patients demonstrated greater involvement in the lower peripheral lung zones bilaterally [14-18]. While these findings are common in COVID-19 patients, they are not specific and can be seen in other conditions such as other viral pneumonia, bacterial pneumonia, injury from drug toxicity, inhalation injury, connective tissue disease, and idiopathic conditions [18].

A significant number of patients may present to small healthcare centers (i.e. urgent care), where radiography is the only imaging modality available. In resource restricted regions, and in areas where there may be a dearth of available radiologists, potentially exacerbated by the pandemic, the utility of augmented AI may be utilized for rapid screening and prompt triage [19]. Suspicious clinical symptoms coupled with positive CXR findings could prompt the need for evaluation with CT Chest.

A number of various AI tools have been developed to segment affected areas of the lung where there alert to the characteristic findings on imaging. Specifically, characteristic findings in CT include ground glass opacities often in a peripheral and subpleural location, as well as focal ground glass opacities which are often times nodular. It should be noted, however, that often times imaging can be negative despite the patient testing positive for Coronavirus.

Applications of AI in interpreting radiographs of various types are numerous, and extensive literature has been written on the topic [22]. Using deep learning algorithms, AI has multiple possible roles to augment traditional radiograph interpretation. These include the potential for screening, triaging, and increasing the speed to render diagnoses. It also can provide a rapid "second opinion" to the radiologist to support the final interpretation. In areas with critical shortages of radiologists, it potentially can be used to render the definitive diagnosis. With COVID-19, imaging studies have been shown to correlate with disease severity and mortality, and AI could assist in monitoring the course of the disease as it progresses and potentially identifies patients at greatest risk [21].

Another commonly reported finding in patients with COVID-19 is the potential for a pro-thrombotic state, which may present clinically with deep vein thrombosis, and pulmonary thrombo-embolic disease [28,29]. The utility of several AI tools has already been described in the evaluation of pulmonary embolism using nuclear medicine ventilation-perfusion scans (V/Q Scans) [30,31]. Computerized clinical decision making tools have been shown to reduce imaging use and increase scan yield [32]. Similar AI augmented programs could further improve patient care by helping to triage patients, and expedite workflow, which could bring flagged to the radiologist for prompt interpretation.

GI

Recently, the presence of bowel abnormalities have also been reported in patients with COVID-19. Findings include bowel abnormalities, particularly ischemia, likely related to small vessel thrombosis. AI tools may be developed further for purposes of detecting intraluminal thrombi in mesenteric vasculature (i.e. SMA, or IMA). Future applications of AI may turn attention to evaluate bowel abnormalities to address these findings. In the case of an evolving pandemic, AI tools may be valuable in assessing and triaging patients rapidly.

Conclusion

Numerous AI augmented imaging interpretation and clinical decision making tools have been developed and shown promise in disease identification, reducing detection times and improving workflow. Continued development and adoption of these adjunct tools has the potential to greatly improve disease response for the current and future pandemics. Further understanding of the various imaging findings and long term effects of COVID-19 are still emerging. Additionally, the ability to use AI in the imaging context in conjunction with other clinical variables may hold promise to offer predictive outcomes.

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