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Original Article

The study on the predictive accuracy of artificial intelligence (AI) Lunit INSIGHT CXR Version 3.0 for pneumonia diagnosis in COVID-19 patients

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Abstract

Background: Millions of people in Thailand have been infected and died from the infection of the COVID-19. As a result, the country's public health system is greatly affected due to the limitation of the number of physicians. Artificial intelligence (AI) is, therefore, used to reduce the working load of physicians in the diagnosis of COVID-19 patients.

Objective: To study on the predictive accuracy of AI Lunit INSIGHT CXR Version 3.0 for pneumonia diagnosis in COVID-19 patients.

Materials and Methods: This study was a retrospective study. The data was collected from 256 confirmed cases of COVID-19 infection admitted as new patients in the Nimibutr Pre-Admission Centre of the Institute of Neurology, the Ministry of Public Health. They were randomly selected from the database.

Seven radiologists and Lunit INSIGHT CXR Version 3.0 software interpret the CXR film to diagnose pneumonia in COVID-19 patients from chest radiographs (CXR).

Results: The research results of the diagnosis of pneumonia in patients infected with COVID-19 between from radiologists and using AI Lunit INSIGHT CXR Version 3.0 software revealed 97.87% (95%CI 88.71-99.95%) of sensitivity, 99.04% (95%CI 96.59-99.88%) of specificity, accuracy = 98.83%, positive predictive value (PPV) = 95.83%, and negative predictive value (NPV) = 99.52%, positive likelihood ratio (+LR) = 102.28, negative likelihood ratio (-LR) = 0.02.

Conclusion: The artificial intelligence software Lunit INSIGHT CXR Version 3.0 can be used to interpret the diagnosis of pneumonia in patients infected with COVID-19 in order to reduce radiologists' workloads during the COVID pandemic when medical staff were limited.

Keywords: Artificial intelligence, Chest radiograph, COVID-19, Diagnosis, Pneumonia.

Introduction

The 2019 coronavirus was officially detected in Wuhan, China in December 2019. It later spread worldwide and was called a pandemic by the World Health Organization (WHO) [1]. During this outbreak, the demand for medical care increased at a rapid rate. Meanwhile, the capacity of medical facilities and health personnel did not increase accordingly [2].

Furthermore, numerous medical officials became afflicted with this disease. As a result, a bigger supply of medical workers was required. Also, because doctors were required to work long hours, they could not provide comprehensive patient care. Many hospitals were opened temporarily to treat the enormous number of patients, and regular hospitals could not accept them. The Nimibutr Pre-Admission Center in the National Stadium was one of many temporary hospitals serving COVID-19 patients [3].

Most COVID-19 patients have respiratory problems, and some have pneumonia, which causes severe symptoms and deaths. Patients with severe symptoms must be rapidly diagnosed to detect pneumonia as soon as possible to provide effective treatment to prevent life-threatening conditions. On the other hand, some cases with positive CXR findings may present with negative RT-PCR testing revealing ground-glass opacity and mixed ground-glass opacity and mixed consolidation [4].

Numerous techniques can be used to examine lung inflammation, including chest computed tomography (Chest CT scan) and chest radiography (CXR). Cleaning the chest computed tomography after use was challenging and time-consuming, which made using it on COVID-19 patients an uphill task. Therefore, the World Health Organization (WHO) does not recommend using chest computed tomography for screening patients [5-9]. The early diagnosis of COVID-19 could control and prevent the spread of the disease and enable physicians to manage patients' disease control [10]. However, a chest radiograph is complicated for general physicians in reading and interpretation [8], and radiologists have difficulty reading CXR due to the indistinct manifestation of radiological features such as consolidation and hazy increased opacities [12-14]. In contrast, radiologists' performance in diagnosing COVID-19 is moderate [10].

Artificial intelligence (AI) is a type of computer science that aims to simulate tasks related to human intelligence and the learning process. In recent years, medical diagnosis employing AI-driven systems has made significant progress in supporting radiologists and clinicians with disease detection, characterization, and monitoring [15]. The application of AI in medical care has been intensively debated to assist medical personnel with the increasing workload in their daily routines—particularly in highly specialized domains such as radiological departments that deal with image-based duties [16,17]. It is a tool that can quickly learn and analyze data in various forms to assure diagnosis accuracy and speed [18]. By easing the burden on medical staff, AI can be used to make interpretations before radiologists confirm them. AI can speed up the performance of chest radiographs [19] and aid in the diagnosis of pneumonia brought on by COVID-19 [20].

During the COVID-19 pandemic, the Nimibutr Pre-Admission Center, the Ministry of Public Health, Thailand, was the temporary center responsible for curing COVID-19 patients because of the limited capacities to receive patients in regular hospitals. Lunit INSIGHT CXR is the AI Software for computer-assisted detection that assists physicians in interpreting chest radiography images which are used in the Nimibutr Pre-Admission center. Despite the fact that there are many studies pertinent to AI use, each AI may result in varied diagnosis results, but only a few researchers explore Lunit INSIGHT CXR.

The effectiveness of using AI to help diagnose pneumonia from COVID-19 is still limited and unclear. The researcher is, therefore, interested in studying the utility of AI in helping clinical diagnosing pneumonia caused by COVID-19 by helping detect lung abnormalities from chest radiographs in patients diagnosed by RT-PCR testing confirmed to be infected. Patients infected with COVID-19 who received care, treatment, and referral at the Nimibutr Pre-Admission Center of the Institute of Neurology, the Ministry of Public Health, between 1 – 30 September 2021 and had their CXR results confirmed by a radiologist by comparing the results of AI for diagnosing pneumonia in patients infected with COVID-19 and the team of radiologists.

Materials and methods

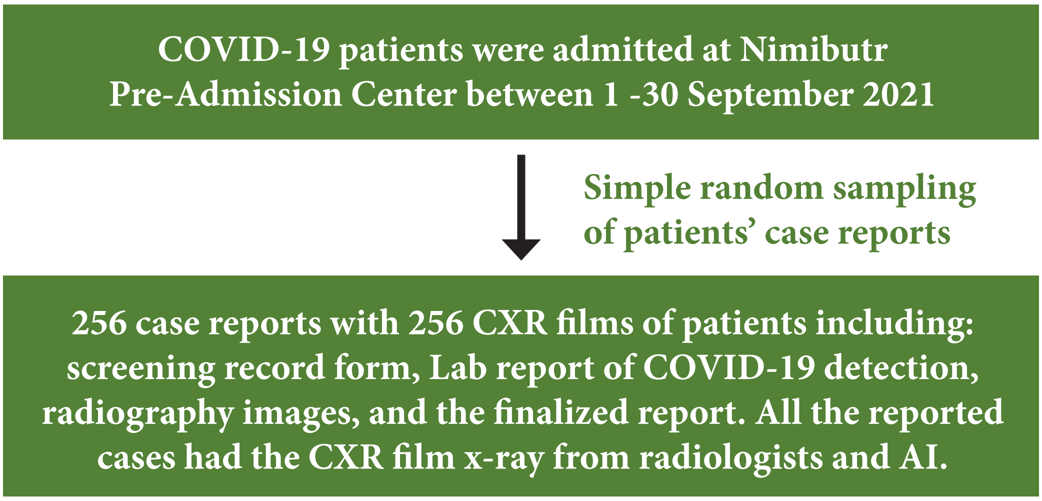
This study was a retrospective study collected from a database of medical records and chest radiographs of a positive RT-PCR confirmed COVID-19 patient admitted as a new patient at Nimibutr Pre-Admission Center of the Institute of Neurology, the Ministry of Public Health. The sample group was the confirmed case of COVID-19, receiving treatment at Nimibutr Pre-Admission Center Between 1 -30 September 2021. The sample size was calculated using G*Power [21] with the result of the suggested collection of 256 patients. Therefore, 256 out of 831 patients who received treatment at Nimibutr Pre-Admission Center Between 1 -30 September 2021 were selected as the sample for this study. Sample random sampling from a medical records database and chest radiographs was employed. Descriptive statistics to analyze general patient information by calculating sensitivity, specificity, and accuracy, including the positive and negative predictive values, were all used to confirm AI's benefits in diagnosing pneumonia caused by COVID-19.

AI, Lunit INSIGHT CXR Version 3.0 software

Lunit INSIGHT CXR is the AI Software for computer-assisted detection that assists physicians in interpreting chest radiography images. The device was designed to analyze chest radiographs via deep learning technology automatically and creates secondary capture DICOM objects reporting the analysis results. Each finding will report the detection-specific radiographic finding: Atelectasis, calcification, cardiomegaly, consolidation, fibrosis, mediastinal widening, nodule, pleural effusion, pneumoperitoneum, and pneumothorax according to the radiographs.

Data collection

The research requested a database of medical records and chest radiographs of a confirmed COVID-19 patient admitted as a new patient at Nimibutr Pre-Admission Center, receiving treatment between 1 -30 September 2021. Those reports included the COVID-19 screening record form, a Lab report of COVID-19 detection, radiography images, and the finalized report. The CXR film's x-rays were obtained into the LUNIT AI system and then were interpreted by radiologists. All the reported cases had the CXR films x-ray from radiologists and AI. Seven radiologists worked under the Department of Medical Services and had expertise in reading films responsible for that.



Figur 1. *Flowchart of patient selection.*

Criteria for separating abnormalities from chest radiographs for diagnosing pneumonia in patients with confirmed COVID-19.

Rama Co-RADS was developed by Suwatanaponched et al. [5] as the categorical assessment scheme of chest radiographic findings in diagnosing pneumonia in confirmed COVID-19 patients. There are six categories of chest radiographic diagnosis. Pneumonia will be confirmed if the CXR film was detected under the category 3 to category 5 of Rama Co-RADS. In this research study, the researcher used the result from radiologists and AI which was interpreted according to the Rama Co-RADS to confirm pneumonia in the patients.

This research received an ethical approval from the Human Research Ethics Committee, the Institute of Neurology, the Department of Medical Services, the Ministry of Public Health, No. 66034.

Results

The study consisted of 256 patients, 140 males (54.69%) and 116 females (45.31%). There were 164 Burmese (64.10%), 41 Cambodians (16.00%), 20 Thais (7.80%), 14 Guineas (5.50%), 15 Laos (5.90%), and two not specified (0.80%) patients' cases in this study (Table 1). Most patients did not have any symptoms during the confirmation of COVID-19. An analysis of the different diagnoses between the demographic data of the patients showed no statistically significant difference (p = .46) between males and females, however, it showed a statistically significant difference between age (p =.00) and nationality (p = .01).

Table 1. *Demographic information of the patients.*

Characteristics	Total (n = 256)	Pneumonia	Non-Pneumonia	P-value
Gender				
Male	140 (54.69)	28	112	.46
Female	116 (45.31)	19	97	
Age (year) **categories**				
< 16	25 (9.77)	4	21	.00**
16 – 30	108 (42.19)	14	94	
31 – 45	99 (38.67)	16	83	
46 – 60	23 (8.98)	12	11	
> 60	1 (0.39)	1	0	
Nationality				
Thai	20 (7.80)	10	10	.01**
Burmese	164 (64.10)	24	140	
Cambodia	41 (16.00)	8	33	
Lao	15 (5.90)	3	12	
Guineas	14 (5.50)	2	12	
Not specifies	2 (0.80)	0	2	
Symptoms				
No	140 (54.69)			
Yes	116 (45.31)			
Pneumonia				
Pneumonia	48(18.75)			
Non-pneumonia	208(81.25)			

Note: * $p < .05$
** $p < .01$

There are three symptom categories of COVID-19 patients classified into three traffic light groups-green, red, and yellow- according to the seriousness of their symptoms. Red refers to the most severe symptoms typically with breathing difficulty; yellow represents mild symptoms; and green means with no signs or such fever, dry cough, or skin rashes. Figure 2 demonstrates the AI chest radiographs of three patients with different symptom categories. Each patient has two radiographs of contour and heatmap films.

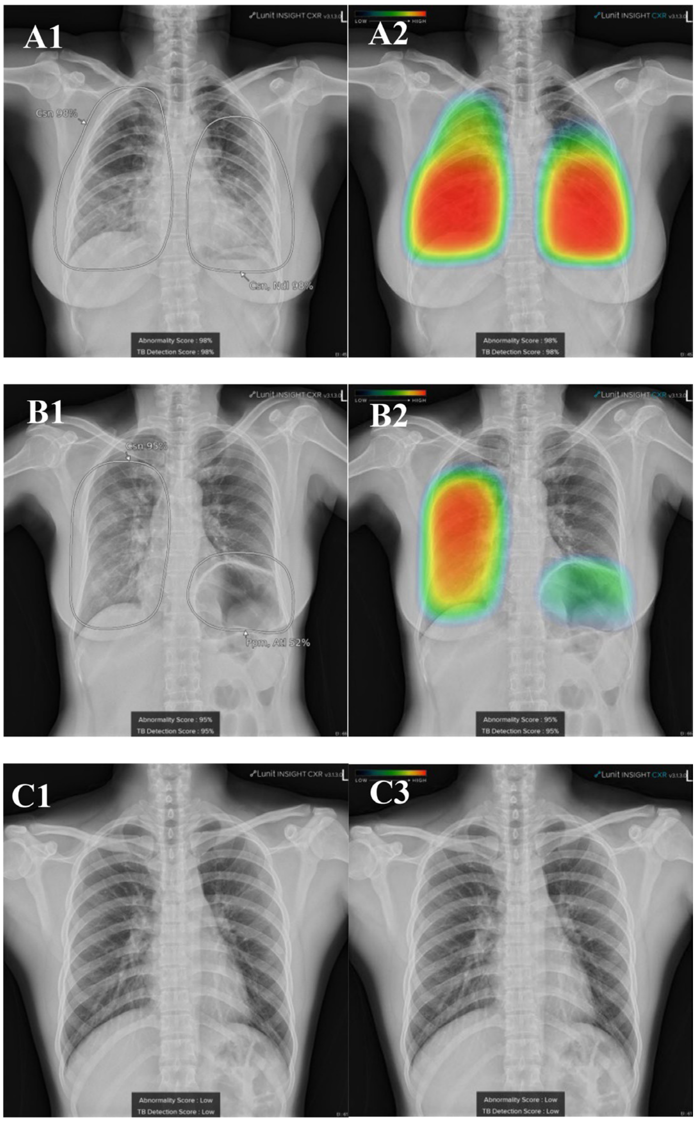


Figure 2. *Chest radiographs with AI interpretation of three different patients. (A1 and A2) The patient diagnosis in red categories with an abnormality score of 98.56% from AI chest radiographs showed that she had pneumonia. (B1 and B2) The patient diagnosis in yellow categories with an abnormality score of 95.11% from the AI chest radiograph showed that she had pneumonia. (C1 and C2) The patient diagnosis in green categories with an abnormality score of 3.54% from AI chest radiograph showed he had pneumonia.*

Test results for diagnosis of pneumonia in patients infected with COVID-19 between radiologists and AI, Lunit INSIGHT CXR Version 3.0 software, following the criteria for separating abnormalities from CXR of Rama Co-RADS [5], had a sensitivity of 97.87% (95%CI 88.71-99.95%), specificity of 99.04% (95%CI 96.59-99.88%) and accuracy of 98.83%. PPV=95.83. % and NPV=99.52%, positive likelihood ratio (+LR) = 102.28, negative likelihood ratio (-LR) = 0.02.

Table 2. *The sensitivity, specificity, and accuracy of AI.*

AI	Detected	Not Detected	Total
Positive	46 (Ture Positive)	2 (False Positive)	48
Negative	1 (False Negative)	207 (True Negative)	208
Total	47	209	256
Sensitivity	97.87% (95%CI 88.71-99.95%)		
Specificity	99.04% (95%CI 96.59-99.88%)		
Accuracy	98.83%		
Positive predictive value (PPV)	95.83%		
Negative predictive value (NPV)	99.52%		
Positive likelihood ratio (+LR)	102.28		
Negative likelihood ratio (-LR)	0.02		

Discussion

The use of imaging in speedy and accurate diagnosis has become extremely critical in the context of the COVID-19 epidemic. This study demonstrated that the commercial AI Lunit INSIGHT CXR Version 3.0 software used was able to identify consolidations associated with pneumonia with a high sensitivity (97.87%) and specificity (99.04%).

Diagnosis of pneumonia in patients infected with COVID-19 requires examination and interpretation of chest radiographs by a team of radiologists, which may take a long time. Due to the limited number of radiologists, it may not be possible to make a timely diagnosis if there are many patients, such as the recent COVID-19 infection. CXRs are the most popularly performed imaging tests; yet, a rapid interpretation of CXRs by radiologists is problematic in hospitals, especially for those with severe lesions [22] and rapid identification of lung infections may result in speedier isolation of patients, potentially reducing the risk of infection spread [23]. Recently, many studies have demonstrated the potential for AI application in radiology as the clinical decision support system (CDSS) or even as a second reading [24] and has great potential for the analysis of large amounts of data. It has played an essential role in preventing the COVID-19 outbreak [25].

For COVID-19 patients, as soon as they receive the treatment, the seriousness of the disease can be reduced. During an ongoing pandemic, chest X-rays were utilized more often, considering their availability and a lower cost [26]. AI in assisting radiologists in diagnosing patients is believed to provide an accurate rate, not a difference from experienced radiologists [19, 27, 25, 28, 29]. With radiologists' workloads increasing, whether AI could be a feasible solution for lowering fatigue and improving the predictive accuracy in an interpreting the diagnosis [30] and it is the other advantage of using AI as non-existence of fatigue, which leads to the risk of errors in interpreting CXRs [31].

The interpretation of CXR, especially regarding pneumonia, is subject to high variability even among radiologists; accordingly, the additional evaluation and highlighting of findings in CXRs by AI is advisable [23]. This AI performed slightly the same level as radiologists, with no statistically significant differences [24], and the AI system can accurately discern between normal and abnormal patients' radiographs and can be used as a triage tool [32]. A study in the same region (Samut Sakhon, central Thailand) in the same year showed that 91.7% of chest radiographs of 629 patients infected with COVID-19 were normal [33]. Our study confirmed that even though there were some false positive and false negative of the AI diagnosis, the amount was still little and likely insignificant for a triage purpose.

Moreover, according to the study of AI Lunit INSIGHT CXR on diagnosis of pneumonia showed no statistically significant differences between AI and radiologists with sensitivity, and specificity of AI of 0.94 (CI95%: 0.94-1.00), 0.90 (CI95%: 0.79-1.00), and 0.95 (CI95%: 0.89-1.00) [24]. Becker et al. [23] study AI can detect pneumonia in chest radiographs with a sensitivity of 95.4%, a specificity of 66.0%, PPV of 80.2% and NPV of 90.8%. Thus, the result from this research can help to confirm the result of the previous studies even though with differences in nationalities.

This study has some limitations. First, it was a retrospective study collected from a database of medical records and chest radiographs of a confirmed COVID-19 patient, with 256 samples from only Nimibutr Pre-Admission Center Between 1 -30 September 2021. This number was very little compared to other studies; however, the researcher employed simple random sampling to select the cases to prevent biases in this study. Second, this study did not measure the accuracy of the radiologists because the study cases were collected from the database. However, all seven radiologists were experts responsible for interpreting the films in the Nimibutr Pre-Admission Center Between 1 -30 September 2021.

Conclusion

The AI of Lunit INSIGHT CXR Version 3.0 software can help read and interpret pneumonia in patients infected with Coronavirus 2019 by sensitivity, specificity, and accuracy equivalent to the interpretation of radiologist results. Therefore, the use of this AI at Nimibutr Pre-Admission Center can assist radiologists in the understanding of CXR. This AI software is recognized and approved for use in helping physicians. In addition, the research results confirm the specificity and accuracy. Moreover, the fact that AI can help read CXR results can be counted as satisfying to confirm the reading results of the first radiologists. Therefore, as the study mainly compared AI with radiologists, it is worth pointing out that it is comparable to the radiologists' reading and thus may potentially be implemented as a decision support or screening tools.

Conflict of interest

The authors declare no conflict of interest.

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