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Optimizing chest X-rays as a leading diagnostic modality for handling COVID-19: a diagnostic study

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ABSTRACT

Recent studies have highlighted that chest CT scans are crucial for accurately diagnosing COVID-19. However, in rural areas of Indonesia, people may have difficulty assessing CT scans, leading to increased undetected cases. To address this issue, we investigated whether chest X-rays (CXR) could replace CT scans in diagnosing COVID-19 patients. A diagnostic cross-sectional-based study was conducted at Fatmawati General Hospital from January to September 2021. The study included suspected COVID-19 patients in isolation wards and ICU who were over 18, with or without comorbidities, and had complete clinical data and laboratory tests. We analyzed imaging data through reverse transcription-polymerase chain reaction (RT-PCR) tests, CXR, and chest CT scans. This study enrolled 150 eligible patients. With RT-PCR as the gold standard, we found that CXR had a sensitivity of 86.6% (95% CI: 78.9-92.3%) and chest CT scan had a sensitivity of 91.1% (95% CI: 84.2-95.6%). Similar performance was observed when detecting ground glass opacities (GGO), bilateral laterobasal, and influenza-like syndrome and dyspnea (ILI) between CXR and CT scans. Receiver operating characteristic (ROC) curves demonstrated that CXR is comparable to CT scan, especially in ground glass opacity (GGO) and consolidation (AUC=0.72; 95% CI: 0.61-0.83 and AUC=0.710; 95% CI: 0.64-0.78). The proposed CXR method can be a reliable primary imaging tool for diagnosing COVID-19 by considering ILI. However, chest CT scans remain the most effective diagnostic method for COVID-19. These findings may be useful for the utilization of CXR for diagnosing COVID-19 in areas with limited access to CT scans.

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1. INTRODUCTION

The SARS-CoV-2 virus is responsible for the global pandemic known as COVID-19. The disease spreads rapidly and causes massive impact, both morbidity and mortality. During this time, detecting respiratory diseases early is critical, and radiological exams are an essential tool [1]. Computer-aided screening tools with greater sensitivity are imperative for disease diagnosis and prognosis as early as possible [2]. Chest X-rays (CXR) are recommended as the initial imaging method because they are efficient, pose a lower risk of radiation exposure, and are more widely available than computed tomography (CT) scans in hospitals [3], [4]. This reduces the chance of viral exposure to staff and patients during pandemics.

Indonesia is a large Southeast Asian archipelago with a high population. However, limited laboratories and staff for real-time reverse transcription-polymerase chain reaction (RT-PCR) diagnostic tests make diagnosing COVID-19 patients challenging [5], [6]. With many remote areas and a dense population, Indonesia's geography creates further obstacles in managing the pandemic [7]. Despite the ongoing pandemic, people in these areas ignored the situation and socially interacted, which significant problem in pandemic management.

The RT-PCR test is widely regarded as the gold standard for detecting viruses in a patient's swab and is commonly used for COVID-19 diagnosis [8]. However, the RT-PCR test has limitations, including the risk of sampling errors, low sensitivity, and the impact of specimen collection timing on accuracy [9]–[11]. Delays in receiving PCR results for clinically suspected COVID-19 patients can impede virus containment efforts. As COVID-19 cases continue to surge, it is crucial to have alternate diagnostic tools available in emergency settings or for rapid diagnosis [12]. Radiological findings, clinical evaluations, medical history, and laboratory tests can aid in early diagnosis, patient classification, and minimizing viral transmission through effective isolation room management, cohorting, and zoning [10]. This approach may also boost cost efficiency and decrease mortality rates, particularly in rural areas and Indonesian hospitals [13].

Opting for CT imaging for COVID-19 patients exhibiting moderate or severe symptoms is advisable [14]. Unfortunately, obtaining a CT scan in Indonesia can be difficult due to limited availability and high costs. Although a chest CT scan is not required for COVID-19 diagnosis, closely monitoring and evaluating isolated patients inwards or in the intensive care unit (ICU) with a portable chest X-ray is critical. While CXRs are more accessible and user-friendly, they are known less sensitive than CT scans [14]–[16]. Nonetheless, they do serve a crucial purpose in detecting COVID-19 pneumonia when PCR tests are delayed, which could increase the risk of viral transmission [17].

A comprehensive investigation is necessary to evaluate the efficacy of CXR versus CT scans in detecting COVID-19, particularly in remote areas where CT scans may not be easily accessible. Nonetheless, only a few papers discuss the potency of CXR to replace CT scans to diagnose COVID-19. No single studies were conducted in Indonesia to investigate CXR and CT scans by also considering the observed clinical signs. The primary objective of this study is to compare the diagnostic performance of CXR and Chest CT scans, with or without clinical indications of pneumonia, against the RT-PCR test. The study also aims to scrutinize imaging characteristics in CXR and CT scans and establish their interrelationship and threshold settings. By conducting this research, we anticipate providing valuable insights into managing COVID-19 patients at Fatmawati Hospital in particular and remote locations across Indonesia in general.

2. METHOD

2.1. Study design and setting

This cross-sectional study was conducted at Fatmawati General Hospital, the referral hospital for COVID-19 in Jakarta, Indonesia. This study was approved by the ethics review committee and Institutional Review Board under the Ministry of Health of Indonesia (Approval Number: B-024/F12/KEPK/tl.00/04/2022). The Declaration of Helsinki protected all participants' privacy and personal identity information. Written informed consent has been obtained from all participants.

2.2. Patients selection

To determine the minimum number of samples required, we assumed that the sensitivity of thorax X-Ray to positive PCR results is 70% while that of CT scan is 85%. This was done at a time when the prevalence of COVID-19 cases in Indonesia was increasing. Using the Lemeshow formula, we obtained a minimum sample size of 165 patients. We collected a total of 150 suspected COVID-19 patients who were referred to the emergency room of Jakarta's Fatmawati General Hospital from January to September 2021. The inclusion criteria were adults over 18 years old, with or without comorbidities, suspected of COVID-19, which required hospitalization in isolation wards and ICU and had complete clinical data and laboratory tests. Children and pregnant women were excluded. Eligible patients received PCR testing, CXR, and CT scans (high-resolution computed tomography) throughout the disease.

Our team collects comprehensive clinical data from patients, including clinical signs, laboratory reports, comorbid factors, and hospital stay duration. We meticulously examine the amalgamation of clinical symptoms, specifically influenza-like syndrome and dyspnea (ILI), with pneumonia indications on radiological output and compare them with RT-PCR findings. ILI is a clinical symptom of cough, dyspnea, and fever. We employ imaging chest X-ray combined with clinical ILI (ILI-Ro) to identify patients with positive ILI and pneumonia on CXR and imaging chest CT scan combined with clinical ILI (ILI-CT) to identify patients with positive ILI and pneumonia on chest CT scans.

2.3. Procedures

Patients underwent baseline chest radiography using state-of-the-art mobile chest radiograph machines. The machines used included Polymobile by Siemens Healthineers in Germany, TOPAZ by DRGEM in Korea, and Multix by Siemens Healthineers in Germany. All films were then processed using computed radiography (CR). For Chest CT examinations, a multidetector CT scanner with 128 slices, Revolution EVO by GE Health Care in the USA was utilized. The CT acquisition parameters were set to 100-120 kVp tube voltage and standard tube current (reference mAs, 60-120) with low-dose technique and automatic exposure control. Slice thickness was set to 0.6-1 mm with a reconstruction interval of 1.0-3.0 mm and a sharp reconstruction kernel. CT images were obtained using low-dose and high-resolution techniques with patients in supine positions without a contrast medium. As part of the hospital's diagnostic procedure, patients received a Chest CT scan at the same time as their X-ray examination.

The CXR and CT images of patients with PCR results were evaluated by three experienced radiologists with over a decade of experience. The radiologists examined the CXR findings to detect features that had been previously stated in the literature. Consolidation/opacities, multifocal ground-glass or patchy infiltrates, lesions on both lungs, and whether there were other findings such as pleural effusion or pneumothorax were identified.

The RT-PCR examination is a laboratory examination used to determine the diagnosis of COVID-19. This examination was taken from airway secretions through a swab in the oropharynx, nasopharynx, or endotracheal aspiration, which tries to discover viruses in the patient's swab, and all the samples are sent and analyzed at an official government laboratory. The lab test requires specialized equipment and takes at least 36-48 hours on average to produce results. The RT-PCR test kit is an official government laboratory kit [18].

2.4. Statistical analysis

Statistical analysis was performed using STATA version 15. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were used to assess diagnostic accuracy. Receiver operator characteristics curve (ROC) analysis was used to determine the threshold values against RT-PCR findings (as a gold standard) and chest CT scans. The study used a goodness of fit test called Concordance statistic (C statistic or C-index) to compare ROC. The confidence interval (CI) was regarded as 95%, and statistical significance was defined as a p-value less than 0.05.

3. RESULTS AND DISCUSSION

Table 1 displays the patient demographics for the study, which included a total of 150 eligible individuals suspected of having COVID-19. Most patients were over 50 years old (57.33%) and over half were male (53.3%). A significant number of patients experienced both ILI (79.33%) and tested positive for COVID-19 through the RT-PCR method (74.67%). Additionally, most patients had positive COVID-19 using CXR (82.67%) and chest CT scans (86.67%).

Table 1. Demographic, clinical characteristic, and diagnostic tests

Data		Frequency (N=150)	%
Sex	Male	80	53.33
	Female	70	46.67
Age	≤50	64	42.67
	>50	86	57.33
RT-PCR	Negative	38	25.33
	Positive	112	74.67
CXR	Negative	26	17.33
	Positive	124	82.67
Chest CT scan	Negative	20	13.33
	Positive	130	86.67
ILI*	No	31	20.67
	Yes	119	79.33

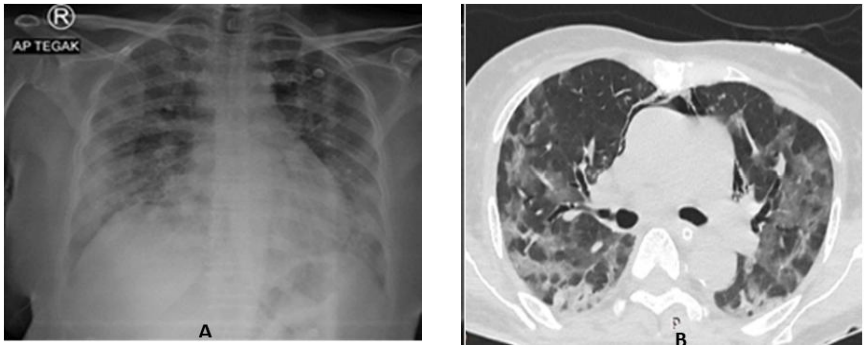
*ILI: Influenza-like syndrome and dyspnea

Table 2 presents the patients' characteristics according to radiological imaging in chest X-rays and CT scans. The CXR showed that the most frequent finding among the patients observed was the ground glass opacity (GGO), which was seen in 118 cases (78.7%) and infiltrates were found to be distributed at laterobasal and bilateral lung areas in 119 patients (79.3%). GGO was also the most common feature in chest CT scans (84%). Of the patients, 51.3% had consolidation; nodules were present in 84 patients (56%), 105 patients (70%) showed abnormality distribution at laterodorsal and bilateral lung areas, and 86% identified a linear fibrotic.

Table 2. Radiologic imaging findings in CXR and chest CT scan (N=150)

Clinical characteristics		CXR (N=150)		Chest CT scan (N=150)	
		n	%	n	%
GGO	Yes	118	78.67	126	84.00
	No	32	21.33	24	16.00
Consolidation	Yes	55	36.67	77	51.33
	No	95	63.33	73	48.67
Distribution of bilateral and laterobasal	Yes	119	79.33	105	70.00
	No	31	20.67	45	30.00
Nodule of halo sign	Yes	43	28.67	84	56.00
	No	107	71.33	66	44.00
Pleural effusion	Yes	31	20.67	35	23.33
	No	119	79.33	127	84.67
Crazy-paving pattern	Yes	0	0	42	28.00
	No	150	100	108	72.00
Bronchiectasis	Yes	0	0	30	20.00
	No	150	100	120	80.00
Linear fibrotic	Yes	0	0	129	86.00
	No	150	100	21	14.00

Illustration 1 and 2 exhibit the disparities in outcomes between CXR and chest CT scans for patients displaying ILI symptoms. The first illustration reveals that CXR detected consolidation, whereas chest CT scan did not. Nevertheless, chest CT scan results offered a more comprehensive identification than CXR. Figure 1 shows a female patient, aged 55, who complained of weakness, cough, dyspnea, and two-week history of fever. Figure 1(a) shows bilateral GGO infiltrates and lung periphery consolidation were detected in the X-ray, while Figure 1(b) provides significant evidence of the presence of GGO accompanied by a bilateral crazy paving appearance and linear fibrotic bands, particularly in the peripheral and posterior-basal regions that can be useful for further analysis. The valuable findings from Figures 1(a) and 1(b) indicate that CXR has the potential to effectively detect GGO infiltrates.

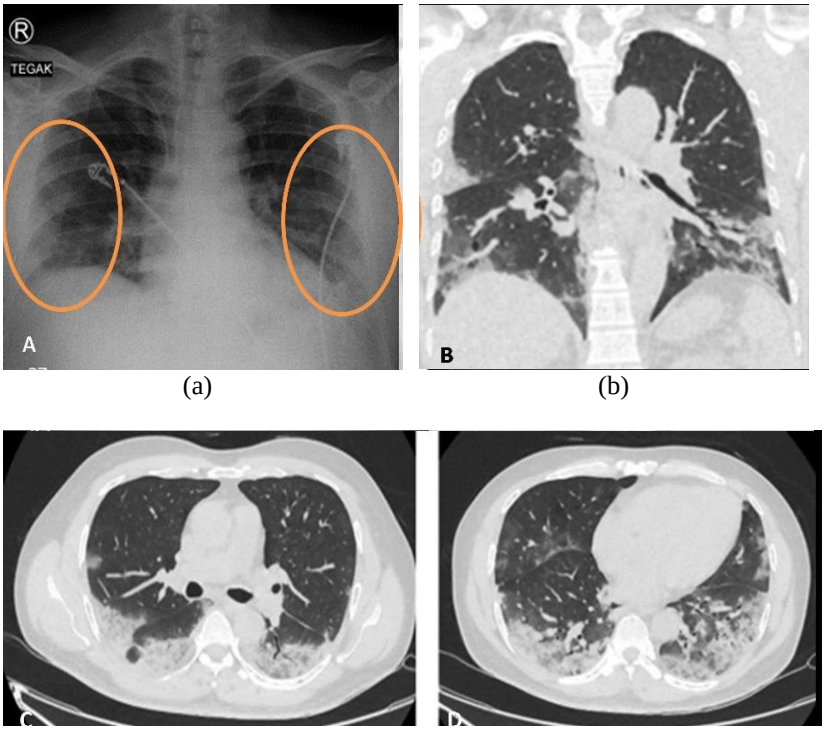


(a) (b)

Figure 1. Radiological imaging of the female patient's chest: (a) X-ray and (b) axial CT scan

Figure 2 shows the result of a 55-year-old male patient presented with weakness, dyspnea, and a one-week history of influenza-like illness. The figure reveals that the chest CT scan was able to identify linear opacities that were not visible in CXR. Figure 2(a) displayed ground-glass opacities (GGO) infiltrates, primarily in the bilateral peripheral areas, with consolidation observed in the laterobasal area. Figure 2(b) and 2(c), revealed bilateral multifocal consolidation, GGO, and linear opacities, particularly in the peripheral and posterobasal regions. The CT scan with the 3D feature was carried out on the same day and provided enhanced. These findings provide additional valuable information for a more accurate diagnosis and treatment plan.

Table 3 compares imaging findings in CXR and CT scans imaging combined with and without clinical signs of ILI against RT-PCR utilizing ROC curves. Ignoring the symptoms of ILI, it appears that a CT scan is better than a CXR in assessing sensitivity, PPV, and NPV against RT-PCR. Meanwhile, the specificity of the two is slightly different, only around 26-28% compared to the RT-PCR method in diagnosing COVID-19. Regrettably, the values of all areas under the curve (AUC) indicate poor correlation, ranging between 0.481 to 0.551, except CT-Nodule and a combination of ILI symptoms with pneumonia on CXR (ILI-RO), which showed a slightly better AUC value of 0.611 (fair). The most sensitive finding was observed in CT-GGO (85.7%), and the most specific finding was seen in RO nodules (78.9%).



(a) (b)

(c)

Figure 2. Radiological imaging of the male patient's chest: (a) X-ray, (b) coronal CT scan, and (c) axial CT scan

Table 3. Comparison of CXR and chest CT scan diagnostic performance, with and without ILI combination, versus RT-PCR

Variables	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	AUC (95% CI)
CXR[1]	86.6 (78.9-92.3)	28.9 (15.4-45.9)	78.2 (69.9-85.1)	42.3 (23.4-63.1)	0.578 (0.500-0.660)
Chest CT scan	91.1 (84.2-95.6)	26.3 (13.4-43.1)	78.5 (70.4-85.2)	50.0 (27.2-72.8)	0.587 (0.510-0.660)
RO GGO[2]	79.5 (70.8-86.5)	23.7 (11.4-40.2)	75.4 (66.6-82.9)	28.1 (13.7-46.7)	0.516 (0.440-0.590)
RO- Cons[3]	35.7 (26.9-45.3)	60.5 (43.4-76.0)	72.7 (59.0-83.9)	24.2 (16.0-34.1)	0.481 (0.390-0.570)
RO- Nodule[4]	31.3 (22.8-40.7)	78.9 (62.7-90.4)	81.4 (66.6-91.6)	28 (19.8-37.5)	0.551 (0.470-0.630)
RO bilateral laterobasal	78.6 (69.8-85.8)	18.4 (7.7-34.3)	73.9 (65.1-81.6)	22.6 (9.6-41.1)	0.485 (0.410-0.560)
CT GGO[5]	85.7 (77.8-91.6)	21.1 (9.6-37.3)	76.2 (67.8-83.3)	33.3 (15.6-55.3	0.534 (0.460-0.610)
CT-Cons[6]	53.6 (43.9-63.0)	55.3 (38.3-71.4)	77.9 (67.0-86.6)	28.8 (18.8-40.6	0.544 (0.450-0.640)
CT Nodule	61.6 (51.9-70.6)	60.5 (43.4-76.0)	82.1 (72.3-89.6)	34.8 (23.5-47.6)	0.611 (0.520-0.700)
CT bilateral laterobasal	68.8 (59.3-77.2)	26.3 (13.4-43.1)	73.3 (63.8-81.5)	22.2 (11.2-37.1)	0.475 (0.390-0.560)
ILI[7]	82.1 (73.8-88.7)	28.9 (15.4-45.9)	77.3 (68.7-84.5)	35.5 (19.2-54.6)	0.556 (0.470-0.640)
ILI-RO[8]	72.3 (63.1-80.4)	50.0 (33.4-66.6)	81.0 (71.9-88.2)	38.0 (24.7-52.8)	0.610 (0.520-0.700)
ILI-CT[9]	75.9 (66.9-83.5)	44.7 (28.6-61.7)	80.2 (71.3-87.3)	38.6 (24.4-54.5)	0.603 (0.510-0.690)

Note: [1]CXR= Chest X-Rays; [2]RO-GGO= Rontgen (CXR) ground glass opacities; [3]RO-Cons= Rontgen (CXR) consolidation; [4]RO Nodule= Rontgen (CXR) nodule; [5]CT GGO= CT scans ground glass opacities; [6]CT-Cons= CT scans consolidation; [7]ILI= Influenza-like syndrome and dyspnea; [8]ILI-RO= Imaging CXR combined with clinical ILI; [9]ILI-CT= imaging chest CT scan combined with ILI

After analyzing imaging features obtained from chest X-ray and CT scan, this study found that bilateral laterobasal distribution (89.5%) and CXR's GGO (85.7%) feature exhibit high sensitivity values. Conversely, CXR consolidation (84.9%) and nodule (83.3%) exhibit high specificity values, as displayed in Table 4. Our ROC curves demonstrate that the AUC of these features ranges between 0.607 and 0.720, indicating fair to good performance.

Table 4. Diagnostic performance of imaging findings in CXR compared to chest CT scan

Variables	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	AUC (95% CI)
GGO*	85.7 (78.4-91.3)	58.3 (36.6-77.9)	91.5 (85.0-95.9)	43.8 (26.4-62.3)	0.720 (0.61-0.83)
Consolidation	57.1 (45.4-68.4)	84.9 (74.6-92.2)	80 (67.0-89.6)	65.3 (54.8-74.7)	0.710 (0.64-0.78)
Nodules/halo sign	38.1 (27.7-49.3)	83.3 (72.1-91.4)	74.4 (58.8-86.5)	51.4 (41.5-61.2)	0.610 (0.54-0.68)
Bilateral laterobasal	89.5 (82.0-94.7)	44.4 (29.6-60.0)	79 (70.6-85.9)	64.5 (45.4-80.8)	0.670 (0.59-0.75)

Note: *GGO= Ground glass opacities

This study seeks to assess the efficacy of CXR radiology as a means of managing COVID-19 treatment in comparison to the existing diagnostic techniques in Indonesia, Chest CT scan and RT-PCR. The prompt identification and precise diagnosis of COVID-19 patients is of utmost importance given the extremely contagious nature of the SARS-CoV-2 virus and the potential for the development of pneumonia, which can result in elevated mortality rates [19]. Moreover, the presence of pulmonary disorder, in particular, can make it challenging to diagnose COVID-19 accurately [20]. In situations where there is a sudden influx of COVID-19 cases and emergency treatment is administered in isolation wards, it is imperative to have a radiological diagnostic method that can swiftly detect COVID-19-related pneumonia and minimize the risk of transmission [4], [13], [21]. By considering such conditions, the present study suggests that examining CXR images can offer a more comprehensive and reliable diagnostic system for identifying such conditions.

CXR images are typically used to detect various pulmonary disorders, such as pneumonia, tuberculosis, and lung cancer. This method could offer a quicker and more reliable diagnosis of these conditions, leading to more effective treatment plans and better patient outcomes [22]. A previous study supported the use of X-ray images due to their accessibility and lower cost [19]. In this study, diagnostic sensitivity by comparing imaging findings with RT-PCR, CXR was found to be 86.6%, but CT scans remained the highest sensitivity in detecting COVID-19 (91.1%). These findings align with a literature conducted by Salameh *et al.* [23] which reported that CT scans had a higher sensitivity of 93.1% compared to CXRs of 82.1% in confirmed cases of COVID-19 but with a low specificity value. Munusamy *et al.* argues that X-ray image processing only helps in detecting COVID-19, while CT scan image processing is accompanied by the ability to determine the severity of the infection [24].

A chest CT scan offers doctors a comprehensive 3D view of the lungs, enabling them to detect abnormalities that may not be visible on a 2D CXR. Figure 1 highlights the distinctions between these two diagnostic tools, underscoring CT scans' superior sensitivity. According to a recent study, CT scans are faster and more cost-effective than RT-PCR tests in detecting COVID-19 [25]. Nevertheless, this study resulted in CXR performing reasonably well overall compared to CT, with all AUC values for various focused variables exceeding 0.60, ranging from 0.61 to 0.72.

Common findings in chest CT scans of individuals with COVID-19 pneumonia consist of ground glass opacities, consolidations, nodules with halo sign, and a crazy-paving pattern with superimposed septal thickening [26]–[28]. CXR may reveal ground-glass opacities, nodules, fibrotic or linear opacities, or consolidation, but these are often bilateral and mainly situated in the lower zone with peripheral opacities. Our research indicates that bilateral laterobasal opacities were present in 79.3% of patients, with a sensitivity of 78.6%. This strengthens the hypothesis that CXRs are a reliable screening and diagnostic tool for detecting typical COVID-19 pneumonia, comparable to CT scans [15], [21], [29], [30].

The study's findings also revealed a weak correlation between CXR and CT scans compared to the RT-PCR. RT-PCR was found to remain the most reliable method. Despite their high sensitivity in detecting COVID-19, both CXRs and CT scans had low specificity values. Some studies support these findings that the low specificity of both tools makes it hard to differentiate between COVID-19 infections and other pneumonia infections [17], [30]. Several studies have pointed out that despite being the most reliable test for COVID-19, RT-PCR has some limitations. The test can have difficulty distinguishing between true positive and true negative COVID-19 cases [31]. A study in China proved that although the RT-PCR testing protocol is quite

strict, it is still possible that this method misses SARS-CoV-2 infection due to difficulties in determining the timing of testing in asymptomatic individuals [32]. This explains why the present study found that 25.3% of individuals who showed clinical signs of COVID-19 pneumonia received negative results on RT-PCR.

Considering clinical symptoms and laboratory tests as biomarkers is crucial for diagnosis [33], [34]. Clinical variables can be incorporated as scores to strengthen COVID-19 diagnoses. Out of 150 samples, patients with ILI clinical features (fever, cough, and dyspnea) had a similar incidence of pneumonia findings on CXR (79.33% vs 82.67%). This may be due to the majority of the samples being from patients with moderate to severe symptoms. We discovered that 79.33% of pulmonary abnormalities were in bilateral laterobasal regions, with ground-glass infiltrates present in 78.7% of CXR. This aligns with Kumar *et al.* evidence review, which concluded that the most specific findings in CXR of COVID-19 patients were bilateral lung involvement (72.8%) and ground-glass opacities (68.5%) [35].

Our study compared the results of RT-PCR, Chest CT scans, and CXR in detecting pneumonia severity. We found that the sensitivity of GGO in CXR was 79.5%, and the most specific imaging findings were nodules (78.9%) and consolidation (60.5%). These findings suggest that CXR is comparable to CT scans in detecting GGO and consolidation. Therefore, CXR has the potential to perform excellently in detecting pneumonia severity, similar to CT scans.

The British Society of Thoracic Imaging and Radiological Society of North America's criteria for typical COVID-19 pneumonia identify consolidation and bilateral laterobasal as specific findings [36]. Our study revealed that CXR consolidation findings are highly specific (84.9%) compared to Chest CT scan, which boasts good accuracy, as shown in Table 4. However, we found that bilateral laterobasal distribution in both CXR and Chest CT scans has low specificity, possibly due to discrepancies in positive results on RT-PCR. Additionally, the literature suggests that similar bilateral laterobasal findings in CXR can occur in other viral pneumonia, such as influenza or organizing pneumonia. Given the pandemic, measurement bias may overestimate CXR, which is especially noteworthy in this study [21], [22], [35].

This study proved a significant contribution for Indonesia to handle COVID-19 as a lesson learned from the previous pandemic. First, it is worth noting that although RT-PCR was defined as a gold standard and CT scans have been proven to predict COVID-19 and its prognosis, this study suggests the CXR is more suitable to be implemented in Indonesia than the CT scan [37]. The utilization of a CXR is critical, particularly in rural regions, for diagnosing lung ailments because of its widespread availability and straightforwardness. Furthermore, CXR remains important as a mandatory modality to determine the condition of the lungs and the severity of pneumonia, taking into account the sensitivity in finding GGO and consolidation which is close to a CT scan. Second, the implementation of the existing mobile X-rays is more efficient when monitoring pneumonia in hospital isolation wards and high-care units. It exposes patients to less radiation than CT scans, making it an ideal tool. Third, in emergency wards, CXRs are essential in identifying those who require hospitalization and guiding clinical management. Serial X-ray assessments offer valuable insight into the progression of pneumonia, which is especially crucial for critically ill patients.

However, we do acknowledge some limitations of the study. First, our data was gathered solely from one hospital network, which may not be representative of patients in other regions. Second, CXR examinations were not conducted simultaneously for all patients based on clinical onset. Third, the samples were not categorized based on their period or clinical onset. Instead, patients requiring hospitalization in isolation rooms or high-care units were selected due to the diverse presentations of COVID-19 and the limited availability of prognostic biomarkers to predict outcomes. Patients with mild symptoms may not seek medical attention, while those with moderate or severe symptoms may require immediate treatment.

4. CONCLUSION

This study explored the potential of CXRs in managing the disease through accurate diagnosis of COVID-19 by considering ILI clinical features and COVID-19-related pneumonia to improve the accuracy of diagnosis. The distribution of pulmonary abnormalities in bilateral and laterobasal areas of the lungs, as well as the presence of consolidation, could be a hallmark of COVID-19 pneumonia. However, further studies on a large scale and simultaneous examinations are necessary to validate these findings.

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