

## ASEAN Movement in Radiology

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# Rama Co-RADS: Cutting-edge tool for improved communication in management and treatment of COVID-19 patients in Thailand

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## Abstract

In Thailand, the rapid and constant rise in the number of confirmed COVID-19 cases, together with the increasing number of patients requiring respiratory and other medical life support during the third wave of COVID-19, has drastically overwhelmed the existing country's healthcare facilities, physicians, and other healthcare workers. Hence, early identification of vulnerable patients at risk and early COVID-19 pneumonia is crucial for timely management and treatment by antivirals or corticosteroids to prevent them from developing severe COVID-19 pneumonia. A prompt chest X-ray report with clear and concise information at baseline screening in alternative healthcare facilities, especially in resource-constrained conditions, is essential. The article presents the use of Rama

Co-RADS, a categorical assessment scheme for chest X-ray findings for diagnosing pneumonia in patients with confirmed COVID-19, in Ramathibodi hospitals. Its use facilitates a rapid, clear, and concise X-ray report despite the various levels of radiologists' experience. Comprehensible and consistent chest X-ray information successfully reduces the time lapse and communication gap among medical staff and assists on-duty, frontline physicians to make prompt and more accurate decisions regarding the management and treatment of COVID-19 patients in accordance with the current national guideline.

**Keywords:** SAR-CoV-2, COVID-19, Chest X-ray, Chest radiograph, Report, Alternative healthcare facilities.

## Introduction

Despite success in containing the number of patients with coronavirus disease 2019 (COVID-19), an emerging infection caused by a novel Coronavirus strain named SARS-CoV-2 during the first and second waves of infection [1,2], Thailand has faced continuous and exponential growth of newly confirmed COVID-19 cases in the third wave since April 2021 [3]. In late July 2021, a constant rise of more than 15,000 confirmed COVID-19 cases per day, together with a substantial amount of unrecovered and critical patients requiring respiratory and other medical life support, has drastically overwhelmed the existing country's healthcare facilities. As of July 30, 2021, the total number of fatal cases has exceeded 4,600 [3]. Of these, patients with risk factors and pre-existing comorbid diseases (e.g., aged >60 years, obesity (>90 kg or BMI >30 kg/m<sup>2</sup>), chronic obstructive pulmonary disease and other chronic lung diseases, chronic kidney disease, uncontrolled diabetes, cardiovascular disease, and cirrhosis) tended to develop severe pneumonia [3]. Early identification of vulnerable patients at risk and with pulmonary involvement in COVID-19 are crucial for addressing timely management and treatment by antivirals or corticosteroids, which prevent patients from developing severe COVID-19 and improve patient outcomes [2,4,5]. Moreover, it helps reduce unnecessary drug prescriptions, which may lead to drug resistance, serious side effects, or other complications [6].

## Management and treatment of COVID-19 in Thailand

In response to the COVID-19 crisis in the third wave, the Department of Disease Control and the Department of Medical Services of the Ministry of Public Health have implemented various case-management strategies and guidelines [7-11]. One of the ongoing case-management strategies is the setting up of alternative healthcare facilities for accommodation, surveillance, and management of confirmed COVID-19 cases identified for positive SARS-CoV-2 using reverse transcription-polymerase chain reaction (RT-PCR). The procedure has been implemented by converting hotels and other feasible facilities to “hospitels” and mobile field medical units, respectively [8-11].

The Department of Medical Services of the Ministry of Public Health has provided several guidelines for managing and treating patients based on the severity of clinical symptoms and pulmonary involvement in COVID-19 in various situations [12]. Table 1 summarizes the current guidelines on clinical practice, diagnosis, treatment, and prevention of healthcare-associated infection for COVID-19 (hereinafter referred to as “the national guideline”), last updated on July 21, 2021 [12].

As shown in Table 1 [12], antiviral drugs are not recommended for asymptomatic COVID-19 patients. Instead, prescribing *Andrographis paniculata* (Fa Talai Jone) capsule may be considered an alternative remedy. To date, favipiravir is an antiviral drug recommended for treating patients with risk factors to develop a severe disease, regardless of the severity of symptoms or the presence of pneumonia. Nevertheless, favipiravir may be considered in patients having mild symptoms or no risk factor to develop a severe disease.

**Table 1.** The guidelines on clinical practice, diagnosis, treatment, and prevention of healthcare-associated infection for COVID-19 by the Department of Medical Services, the Ministry of Public Health, last updated on July 21, 2021 [12].

Group	Clinical Symptoms and Severity	Recommendations for Management and Treatment
1	Asymptomatic cases	<ul style="list-style-type: none"> <li>Recommend admitting the patients in a hospital or an alternative government-supported healthcare facility for at least 14 days from the day the patients are tested positive</li> <li>Provide supportive care without prescribing antivirals</li> <li>Consider prescribing <i>Andrographis paniculata</i> (Fa Talai Jone) capsule</li> </ul>
2	Cases with mild symptoms, without pneumonia and any risk factors for a severe disease <sup>1</sup>	<ul style="list-style-type: none"> <li>Recommend admitting the patients in a hospital or an alternative government-supported healthcare facility for at least 14 days from the day the patients are tested positive, or until symptoms improve for at least 24-48 hours</li> <li>Provide supportive care</li> <li>Consider prescribing favipiravir</li> </ul>
3	Asymptomatic or symptomatic cases <ul style="list-style-type: none"> <li>With a risk factor for a severe disease or major comorbidities<sup>1</sup> OR</li> <li>With mild pneumonia that does not meet the criteria below</li> </ul>	<ul style="list-style-type: none"> <li>Recommend hospitalization for at least 14 days from the onset of symptoms or until symptoms improve</li> <li>Prescribe favipiravir for 5 days or more, depending on clinical symptoms</li> <li>May consider administering corticosteroids plus favipiravir in patients with worsening lung symptoms<sup>2</sup> and chest X-ray findings</li> </ul>
4	Confirmed pneumonia with hypoxia (resting SpO <sub>2</sub> at room air ≤96%), or with SpO <sub>2</sub> at room air drops ≥3% from the first measured value during exertion (exercise-induced hypoxia), or with progression of pulmonary abnormalities on a chest X-ray	<ul style="list-style-type: none"> <li>Prescribe favipiravir for 5-10 days depending on clinical symptoms</li> <li>Administer corticosteroids</li> <li>May consider concomitant prescription of lopinavir/ritonavir for 5-10 days</li> </ul>

<sup>1</sup>Age >60 years, chronic obstructive pulmonary disease and other chronic lung diseases, chronic kidney disease, cardiovascular disease including congenital heart disease, stroke, uncontrolled diabetes, obesity (>90 kg or BMI >30 kg/m<sup>2</sup>), cirrhosis, immunosuppression, and lymphocyte <1,000 cells/mm<sup>3</sup> or patients without risk factors but more likely to have more severe disease

<sup>2</sup>Resting SpO<sub>2</sub> at room air ≤96%, or with SpO<sub>2</sub> at room air drops ≥3% from the first measured value during exertion (exercise-induced hypoxia)

## **Ramathibodi hospitals as alternative healthcare facilities for COVID-19**

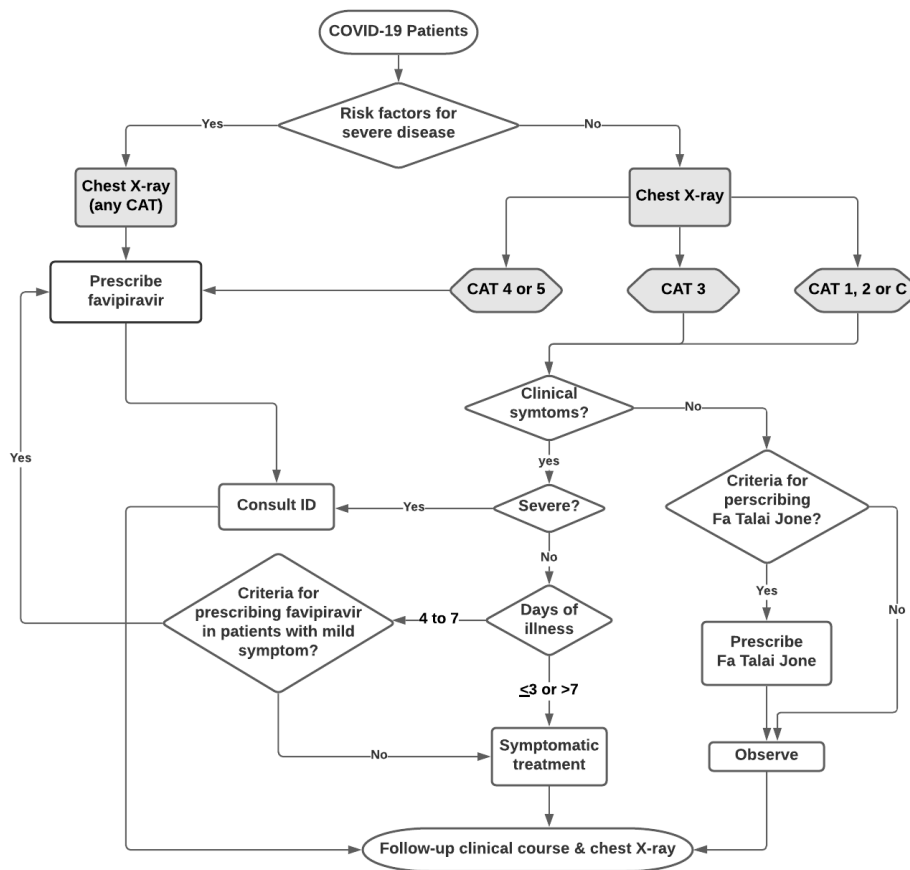
In mid-April 2021, the Faculty of Medicine Ramathibodi Hospital, Mahidol University, in collaboration with partner hotels, established alternative healthcare facilities (hereinafter referred to as “Ramathibodi Hospitals”). Physicians and healthcare staff working in the hospitals are allocated from different departments, under close supervision of infectious disease (ID) physicians.

The rapid rise in COVID-19 cases, which has eventually overwhelmed the hospitals, led to a substantial increase in patients with moderate severity and multiple comorbidities admitted to the hospitals. Due to shortage of infectious disease (ID) specialists, on-duty, frontline physicians allocated from different departments to the hospitals are responsible not only for initial screening for risk factors and pulmonary involvement but also for determining the onsite management and treatment by following the workflow for management and treatment of COVID-19 patients in the hospitals (hereinafter referred to as the workflow). The current workflow chart (Figure 1) provided by the Division of Infectious Disease, Department of Medicine, Faculty of Medicine Ramathibodi Hospital is consistent with the national guideline (Table 1).

Since COVID-19 patients can remain asymptomatic despite having pulmonary involvement or have rapid change in the clinical course, chest imaging becomes essential in COVID-19 pandemic [5,13-17]. Although chest computed tomography (CT) appears to be associated with higher sensitivity, specificity, and accuracy than chest X-ray [15-17], there is no evidence to support CT screening for pulmonary involvement in asymptomatic patients or when the pulmonary involvement is readily visible on the chest radiography. In the limited or constrained resources, chest CT is not recommended as a screening and monitoring tool. It should instead be performed to answer specific clinical problems contributing to the patient’s management [15-17]. Considering the cost-effectiveness, low radiation exposure, rapid execution, and low risk of infection transmission to the radiology staff and uninfected patients [5,15-18],

multiple countries are still using chest X-ray, particularly portable chest X-ray, as a first-line triage tool for diagnosis, assessing the severity of the COVID-19 infection, and excluding an alternative diagnosis. It is also helpful for disease monitoring and detecting complications, especially in critical care settings [5,15,19,20].

To facilitate timely diagnosis, management, and treatment, all patients admitted to the Ramathobodi Hospitals are required to undergo chest X-ray examinations using a mobile or portable X-ray unit at admission and during hospital admission, scheduled for illness days 5-7 and 10-12 after the symptom onset.



**Figure 1.** The workflow chart for the management and treatment of COVID-19 patients in Ramathibodi hospitals.

## Radiology movement in COVID-19

The role of the Department of Diagnostic and Therapeutic Radiology, Faculty of Medicine Ramathibodi Hospital is to set up a portable X-ray unit and allocate radiology technicians to work with frontline physicians in each hospital. Since a chest X-ray report is essential for further management and treatment, all chest X-rays must be reported as fast as possible. Hence, radiologists are assigned from all subspecialties of Radiology for film interpretation daily. However, the increasing number of chest X-rays performed, time restraint, and the different levels of radiologists' experience contributed to the diversity and ambiguity of the chest X-ray reports in the early phase. The time lapse and communication gap in chest X-ray reporting among on-duty, frontline physicians at baseline screening led to unnecessary consultations with the supervising ID specialists and delayed treatment.

In this context, a standardized reporting system can mitigate the problems by reducing variations and turnaround time for chest X-ray reporting [21-23]. However, the readily available standardized reporting systems for chest CT and chest X-ray of pulmonary involvement in COVID-19 published in the literature [15,24-27] are unfit for management of the current COVID-19 situation of Thailand.

First of all, it is unsuitable to use the expert consensus statement on chest CT findings related to COVID-19, endorsed by the Radiological Society of North American, the Society of Thoracic Radiology, and American College of Radiology [24], and COVID-19 Reporting and Data System (CO-RADS) proposed by the COVID-19 Standardized Reporting Working Group of the Dutch Radiological Society [25] for chest X-ray reporting. It is because some CT findings, for example, the crazy-paving appearance and thickened vessels, cannot be readily depicted on a chest X-ray [24,25]. Moreover, both the expert consensus statement on chest CT findings and CO-RADS are intended to enable the diagnosis of COVID-19 in a patient suspected of having COVID-19 before getting an RT-PCR result [25], not in a confirmed COVID-19 case as in our clinical setting.



Secondly, the suggested reporting language of chest radiographic findings proposed by Litmanovich et al. [15] and the structured reporting template for portable chest X-rays presented by Yates et al. [26] are also used for early evaluation of a patient suspected of having COVID-19 [15,26]. Therefore, it is not appropriate to use them for triage of confirmed COVID-19 patients in our clinical situation.

Thirdly, the CO X-RADS proposed by De Sanctis et al. [27] is intended to evaluate the clinical and radiological severity of COVID-19 in symptomatic patients with confirmed COVID-19 admitted to main hospitals. Accordingly, it does not fit the current clinical setting in Thailand. Moreover, CO X-RADS (0-IV) using a sum of radiological severity score (range, 0-10) of various pulmonary abnormalities on chest X-rays [27] is a complicated and time-consuming task, precluding fast reporting for prompt decision, timely management, and treatment in alternative healthcare facilities.

## Rama Co-RADS

To respond to the ongoing and pressing challenges on patient triage in hospitals, Suwatanapongched et al. [28] proposed an alternative categorical assessment scheme of chest X-ray findings for the diagnosis of pneumonia in patients with confirmed COVID-19 (hereinafter referred to as “Rama Co-RADS”) (Table 2). Rama Co-RADS was designed based on Ramathibodi’s experiences in the first and second waves of COVID-19 in Thailand and previously published studies [14,15,29,30] using the standardized reporting systems for chest CT and chest X-ray COVID-19 published in the literature [15,24-26] as the framework.

As shown in the previous studies, COVID-19 pneumonia shares similar chest X-ray and chest CT findings [14,15,18,29,30]. The presence of poorly defined patchy opacities or consolidations in a peripheral distribution or rounded morphology on chest X-rays raises the likelihood of being COVID-19 pneumonia in the pandemic setting, especially in the confirmed cases (Figures 2B,3-5).



Rama Co-RADS provides six categories, i.e., categories 1-5 and additional category C (Table 2) [28]. As shown in Table 2, the categories in Rama Co-RADS refer to six likelihood levels of COVID-19 pneumonia on chest X-rays in confirmed COVID-19 cases. The likelihood level increases from negative or very low in Rama Co-RADS category 1 to very high in Rama Co-RADS category 5.

**Rama Co-RADS category 1** indicates a normal chest X-ray [28] and implies a negative or very low likelihood of having pulmonary involvement in COVID-19.

**Rama Co-RADS category 2** denotes minor abnormalities unrelated to COVID-19 pneumonia on a chest X-ray and also implies a negative or very low likelihood of having pulmonary involvement in COVID-19. Examples are anatomical variants (e.g., breast implants, scoliosis, and old bony fractures), features favoring minor technical issues (e.g., rotation, suboptimal inspiration, inadequate exposure) not affecting film interpretation, and irrelevant abnormalities (e.g., old tuberculosis (TB), mild cardiomegaly, aortic atherosclerosis) requiring no treatment [28].

**Rama Co-RADS category C** (Figure 2A) indicates atypical chest X-ray findings inconsistent with COVID-19 pneumonia and suggests other clinically significant diseases. Examples are bacterial pneumonia, active TB, congestive heart failure, pneumothorax, pleural effusion, and malignancy. This category implies a low likelihood of COVID-19 pneumonia. Unlike minor abnormalities listed in category 2, these abnormalities are clinically significant and warrant further proper management and treatment. Rama Co-RADS category C also includes the severe technical artifacts impeding accurate film interpretation for COVID-19 pneumonia. A repeated chest X-ray on the following day is recommended [28].

**Rama Co-RADS category 3** (Figure 3) indicates the presence of equivocal/unsure/indeterminate findings on a chest X-ray. Since early/mild/atypical pulmonary involvement in COVID-19 can manifest as subtle, poorly defined opacities indistinguishable from other causes (e.g., pseudolesions, other diseases) [29], Rama Co-RADS category 3 implies a moderate likelihood of COVID-19 pneumonia. Hence, a patient should receive a clinical evaluation for respiratory symptoms and undergo a follow-up chest X-ray within the next 1-2 days [28].

**Rama Co-RADS category 4** (Figures 2B and 4A) requires the presence of single or multifocal poorly defined ground-glass opacities, consolidations, or both in the unilateral lung. These findings are considered suspicious for early/mild COVID-19 pneumonia [15,19,26,28,29] and, therefore, implies a high likelihood of COVID-19 pneumonia.

**Rama Co-RADS category 5** (Figure 5) requires the presence of typical findings for COVID-19 pneumonia, i.e., multifocal, peripheral opacities (ground-glass opacities, consolidations, or both), including those with rounded morphology, in bilateral lungs. This category implies a very high likelihood of COVID-19 pneumonia [15,19,26,28,29]. Timely treatment with antivirals ( $\pm$  corticosteroids if indicated) and close follow-up, especially in a high-risk patient, are mandatory [4,12].

Rama Co-RADS category 5 generally reflects a greater extent of pulmonary involvement, implying more severe COVID-19 pneumonia than Rama Co-RADS category 4. Nevertheless, it is essential to note that categories 4 and 5 do not reflect the overall disease extent or severity of pneumonia, which may vary differ among patients. As the disease progresses or regresses, a dynamic or temporal change is inevitable (Figures 2, 4, and 5) [13-15,19,20].

When chest X-ray findings fit more than one category, the chest X-ray should be designated with the higher Rama Co-RADS category [28]. For example, a chest X-ray shows subtle equivocal opacities in one lung (Rama Co-RADS category 3) and multifocal, poorly defined ground-glass opacities in another lung (Rama Co-RADS 4), the chest X-ray should be assigned to Rama Co-RADS category 4. When another clinically significant disease coincides with a single poorly defined ground-glass opacity or consolidation, the chest X-ray should be assigned to Rama Co-RADS category 4 (Figure 2B).

The standardized description and interpretation of Rama Co-RADS facilitate radiologists to provide a rapid, precise, and concise chest X-ray report regarding the presence or absence of pneumonia in patients with confirmed COVID-19, despite the different levels of experiences.

Since applying Rama Co-RADS for chest X-ray reporting in Ramathibodi Hospitals on 26 April 2021, there has been a reduction in the median turnaround X-ray reporting time, the time lapse, and the communication gap among healthcare staff. As of 31 May 2021, the median turnaround X-ray reporting time reduced by 24%, compared with the time spent before using Rama Co-RADS [28].

At present, Rama Co-RADS has been adopted by other alternative healthcare facilities provided by different government agencies, for example, the Regional Health 8 Office of the Ministry of Public Health and the RadioVolunteer project [28,31,32]. The RadioVolunteer project is the collaboration of the Royal College of Radiologists of Thailand, the JF AdvanceMed Co.,LTD, and 328 Thai radiologists to help provide chest X-ray reporting of COVID-19 patients in the Medical Correctional Institution in Bangkok and prisons in all parts of Thailand.

**Table 2.** Rama Co-RADS: categorical assessment scheme of chest X-ray findings for diagnosing pneumonia in patients with confirmed COVID-19.

Rama Co-RADS	Likelihood of COVID-19 Pneumonia	Impression	Chest X-ray Findings
<b>Category 1</b>	Negative or very low	Normal chest X-ray	<ul style="list-style-type: none"> <li>No abnormality detected</li> </ul>
<b>Category 2</b>	Negative or very low	Minor abnormalities unrelated to COVID-19 pneumonia	<ul style="list-style-type: none"> <li>Anatomical variants (e.g., breast implants, scoliosis, and old bony fractures)</li> <li>Features favoring minor technical issues (e.g., suboptimal inspiration, inadequate exposure) but not affecting film interpretation</li> <li>Irrelevant abnormalities (e.g., old tuberculosis (TB), mild cardiomegaly, aortic atherosclerosis)</li> </ul>
<b>Category C</b>	Low	Low probability or atypical for COVID-19 pneumonia, but with other clinically significant diseases requiring clinical correlation and further management	<ul style="list-style-type: none"> <li>Other clinically significant diseases (e.g., bacterial pneumonia, active TB, congestive heart failure, pneumothorax, pleural effusion, malignancy)</li> <li>Presence of severe technical artifacts affecting film interpretation and requiring a repeated or follow-up chest X-ray</li> </ul>
<b>Category 3</b>	Moderate	Equivocal/unsure/indeterminate for COVID-19 pneumonia	<ul style="list-style-type: none"> <li>Some features (e.g., subtle, poorly defined opacities) that may represent early/mild/atypical COVID-19 pneumonia or other causes (e.g., pseudolesions, other diseases) requiring clinical correlation and follow-up chest X-ray</li> </ul>
<b>Category 4</b>	High	Suspicious for early/mild COVID-19 pneumonia	<ul style="list-style-type: none"> <li>Single or multifocal poorly defined ground-glass opacities or consolidations in the unilateral lung</li> </ul>
<b>Category 5</b>	Very high	Typical for COVID-19 pneumonia	<ul style="list-style-type: none"> <li>Multifocal peripheral opacities (ground-glass opacities and/or consolidations), including those with rounded morphology, in bilateral lungs</li> </ul>

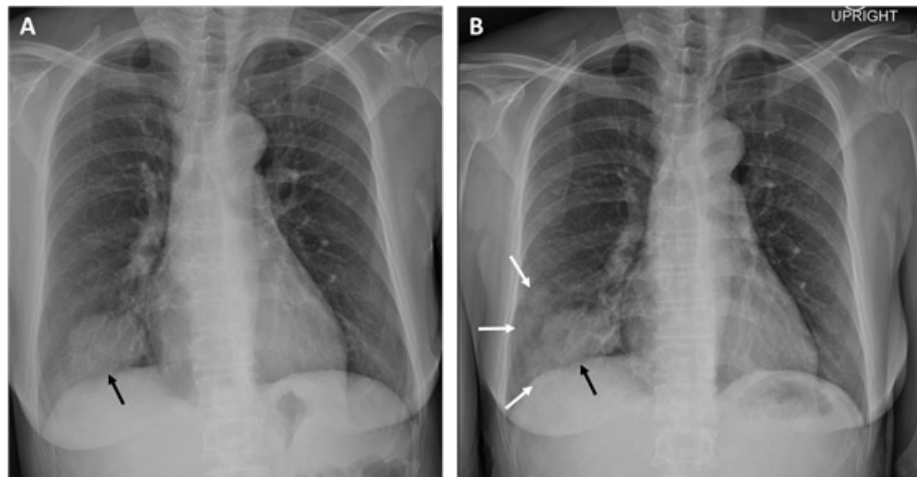
\*Adapted from Suwatanapongched T, et al. Rama Med J 2021;44(2):50-62 [28].

## **Rama Co-RADS for communication, management, and treatment of COVID-19**

A chest X-ray report denoting Rama Co-RADS category 1 and 2 or C implies a negative/very low or low likelihood of COVID-19 pneumonia. Therefore, on-duty physicians can follow the workflow without consulting ID specialists (Figure 1). Since a negative chest X-ray may result from a lack of pulmonary involvement, an early course of infection, or subtle pulmonary involvement beyond the resolution of plain radiography, follow-up chest X-ray is required for disease monitoring, especially in high-risk or symptomatic patients [19].

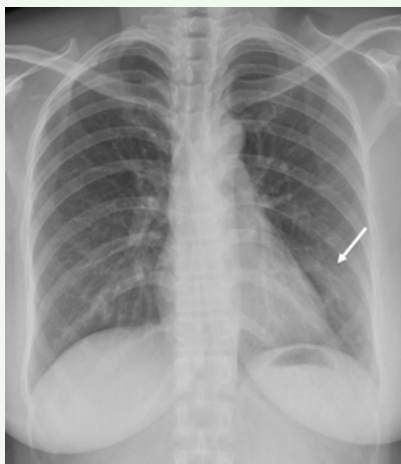
A chest X-ray denoting Rama Co-RADS category 4 or 5 implies, respectively, a high or very high likelihood of COVID-19 pneumonia (Figure 2B, 4, 5). Regardless of symptoms and risk factors, on-duty physicians can bypass a consultation with ID specialists and prescribe antivirals ( $\pm$  corticosteroids, if indicated) to these patients (Figure 1).

A chest X-ray report denoting Rama Co-RADS category 3 (Figure 3) implies a moderate likelihood of COVID-19 pneumonia. In this regard, the on-duty physician needs to consult the supervising ID specialists for further opinion, management, and treatment (Figure 1).



**Figure 2.** A 55-year-old woman with positive RT-PCR.

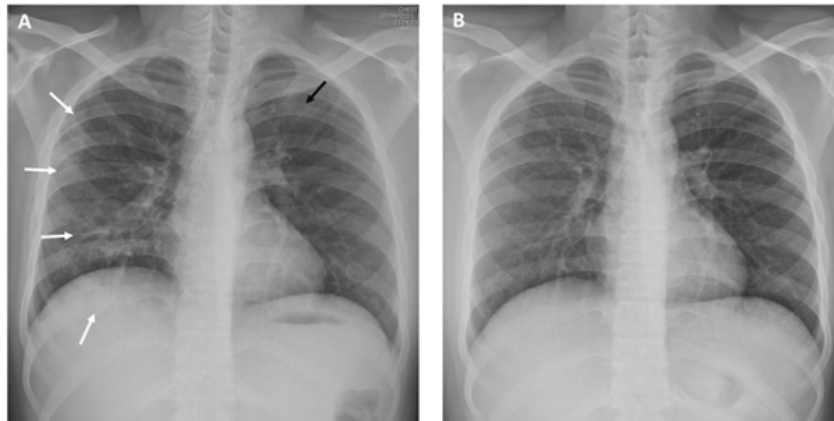
(A) The admission chest X-ray was obtained 7 days after the symptom onset. It shows a sizeable pulmonary mass (black arrow) in the right lower zone. The finding is atypical for COVID-19 pneumonia but raises the concern regarding lung cancer. This important finding should be categorized as Rama Co-RADS category C and warrants further workup. (B) The follow-up chest X-ray was obtained 2 days later. It shows newly developed opacities (white arrows) with rounded morphology around the pre-existing right lower lung mass (black arrow). The remaining lungs are clear. The new findings should now be categorized as Rama Co-RADS category 4, which raises the high likelihood of COVID-19 pneumonia.



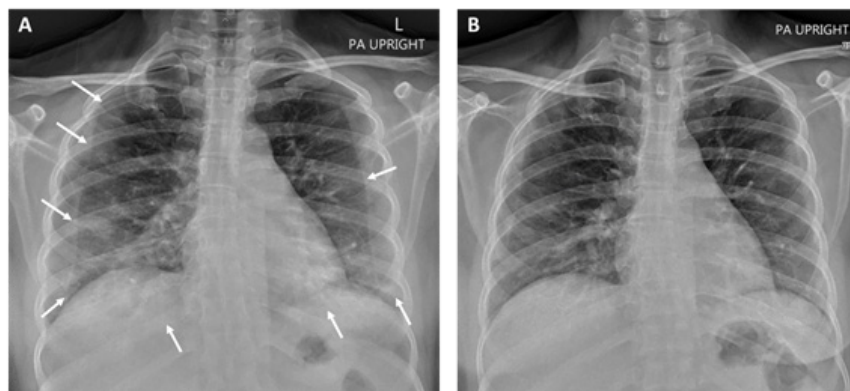
**Figure 3.** A 39-year-old woman with positive RT-PCR.

The admission chest X-ray obtained 10 days after the symptom onset shows subtle, poorly defined opacities (arrow) in the left lower zone, which might represent early COVID-19 pneumonia or pseudolesions caused by the overlapping ribs and pulmonary vessels. The findings are considered Rama Co-RADS category 3. However, due to late presentation and lack of clinical symptoms or risk factors, the ID specialist decided to discharge the patient the following day for monitoring as a home isolation case, without requesting chest X-ray follow-up and prescribing antiviral treatment.





**Figure 4.** A 20-year-old man with fever, cough, dyspnea, anosmia, and positive RT-PCR. (A) The admission chest X-ray was obtained 15 days after the symptom onset. It reveals multifocal, poorly defined opacities (white arrows) in all zones of the right lung (most pronounced in the lower zone); findings are suspicious for COVID-19 pneumonia. Also, subtle, poorly defined opacities in the left upper zone (black arrow) are noted, representing either early pneumonia or pseudolesions caused by the overlapping structures. Since the opacities in the left upper zone are considered equivocal, the chest X-ray findings should be categorized as Rama Co-RADS category 4. (B) The follow-up chest X-ray was obtained 23 days after the symptom onset and 8 days of favipiravir and prednisolone treatment. It shows marked radiographic improvement along with remission of all clinical symptoms.



**Figure 5.** A 44-year-old woman with cough and positive RT-PCR. (A) The admission chest X-ray was obtained 7 days after the symptom onset. It shows multifocal, bilateral, poorly defined opacities (arrows), more pronounced on the right lung and the lower zones. The findings are typical for COVID-19 pneumonia corresponding to Rama Co-RADS category 5. (B) The follow-up chest X-ray was obtained 12 days after the symptom onset and 5 days of favipiravir and dexamethasone treatment. Significant radiographic improvement is evident along with clinical remission.



## Conclusion

In the current and unprecedented COVID-19 situation which overwhelms the country's existing healthcare facilities, physicians, and other healthcare staff in Thailand, early identification of vulnerable patients at risk and early COVID-19 pneumonia on chest X-ray is crucial for addressing timely management and treatment by antivirals or corticosteroids to prevent them from developing severe COVID-19 pneumonia. Incorporating a categorical assessment scheme in Rama Co-RADS into the radiology workflow helps facilitate rapid, clear, and concise chest X-ray reports, and reduces the time lapse and communication gap among healthcare staff. Its use successfully assists on-duty, frontline physicians in the alternative healthcare facilities to make prompt and more accurate decisions regarding the management and treatment of COVID-19 patients following the current national guideline.

## Author contributions

The authors have made a substantial, direct and intellectual contribution to the work and approved it for publication.

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