Characteristics of COVID-19 Chest Radiography in the Brixia, RALE and Modified Dr. Soetomo Hospital Scoring System

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Abstract

COVID-19-confirmed patients require further evaluation using chest radiographs for clinical estimation and management. The availability of assessment tools for chest radiographs can help determine the distribution of locations and radiological features. The authors seek to investigate the pattern of the chest radiography between Brixia, RALE, and Modified Dr. Soetomo Hospital scoring system. This study was a retrospective with descriptive analysis on confirmed cases at Dr. Soetomo Hospital, Surabaya, Indonesia. A total of 604 samples were patients who were hospitalized at Dr. Soetomo Hospital and already has the results of the initial chest X-ray at Dr. Soetomo Hospital. Based on the distribution of the location of the lesions, according to three observers, the most common was a combination of the middle-lower zone with peripheral and bilateral dominance. Radiological feature shows a combination of interstitial and alveolar infiltrates (dominantly alveolar). In this study, the average degree of severity according to the Brixia Score, RALE Score and Modified Dr. Soetomo Hospital scoring system showed moderate to severe pneumonia.

Keywords : Radiological Feature ; Confirmed Cases ; Brixia ; RALE ; Modified Dr. Soetomo Hospital

1. Main text

Confirmed cases were defined as patients infected by the COVID-19 virus, which are proven by real-time Reverse-Transcriptase Polymerase Chain Reaction (rRT-PCR) laboratory examination. There are two categories of confirmed cases, infections accompanied by symptoms and without any clinical manifestations[1]. Roughly 80% of cases were classified as mild or moderate, 13,8% were severe, and the rest 6,1% were in critical condition[2]. On 31st of December 2019, the WHO China Country Office reported the first few cases of pneumonia of unknown etiology in Wuhan City, Hubei Province, China, which was later identified as a novel variant of coronavirus. Afterward, the number of victims soared and spread throughout nations immediately[1].

Radiology has played a notable role in diagnosing and assessing this entity, although the final diagnosis relied upon real-time Reverse-Transcriptase Polymerase Chain Reaction (rRT-PCR) examination for the existence of the coronavirus[3]. Plain chest radiographs were the primary imaging option for most physicians to evaluate the patient with COVID-19 pneumonia, either confirmed or suspected[4]. According to the British Society of Thoracic Imaging, the primary pattern of probable COVID-19 was multiple opacities, predominantly at the peripheral basal of both lungs[5]. Despite being insensitive to the detection of pulmonary involvement in the earlier stage of the disease, the plain chest radiograph is a diagnostic tool to monitor the evolution of lung

abnormality in COVID-19 patients, particularly those in intensive care units. The quantity measure of radiology imaging in observing the pathology evolution in the lung is paramount to ascertain the proper clinical management and breathing assistance device for infected patients, with the aid of the chest radiograph scoring system to rule the pulmonary involvement in COVID-19. The first measurement tool was introduced by Borghesi and Maroldi in 2020[6], namely Brixia Score. Thereafter, recent studies were advancing in inventing other scoring systems, which were adapted from the Radiographic Assessment of Lung Edema (RALE) score, assessing the lung implications shown by consolidation[7]. Further research was expanded by Setiawati et al., 2021[8], explaining that this scoring system can assist in determining the severity of COVID-19 disease in 115 patients.

The Brixia Score has been widely used as the severity assessment tool and to evaluate the progression of chest X-rays at Tongji Hospital, Wuhan, and Azienda Socio Sanitaria Territoriale, Spedali Civili of Brescia, Italia. Conversely, the RALE scoring system was utilized at Queen Mary Hospital Hong Kong, Pamela Youde Nethersole, Hospital Hong Kong, Shenzhen Hospital, and Careggi University Hospital. A contrasting difference between both frameworks is that the RALE score was commonly used by general physicians owing to its straightforwardness in evaluating COVID-19 severity, although the system only divided the lungs into two areas; therefore, it was unspecific for smaller lesions. On the contrary, the Brixia score was settled by trained radiologists for this system. Furthermore, the third scoring system, Modified Dr. Soetomo Hospital scoring system, is adapted from previous frameworks redesigned to meet the necessity and resources of Dr. Soetomo Hospital[8].

Based on the aforementioned background, the authors were eager to continue the previous study with larger samples to establish the radiologic pattern of chest radiographs in COVID-19 confirmed cases hospitalized at Dr. Soetomo Hospital Surabaya and to measure their severity degree using Brixia, RALE, and Modified Dr. Soetomo Hospital scoring system, along with appraising the correlation of each framework. The findings were expected to assist radiologists in providing valuable information about the distribution location, radiologic pattern, and severity score alongside the analysis of each manner to be applied appropriately at Dr. Soetomo Hospital.

2. Study Design, Location, and Timeframe

This study was a retrospective with descriptive analysis on confirmed cases at Dr. Soetomo Hospital, Surabaya, Indonesia. Data were taken from confirmed case's medical record and hospitalized at Dr. Soetomo Hospital from May to June 2020. This study was conducted in accordance with the Declaration of Helsinki. This study has met the ethical principles of and received approval from the Research Ethics Committee of Dr. Soetomo Hospital, Surabaya. Reference number: 0803/LOE/301.4.2/II/2022.

2.1 Population and Sample

The project involved 604 research subjects meeting the inclusion and exclusion criteria. Each image underwent careful evaluation for lesion distribution, classification, and degree of severity by three radiologists and was inscribed in the provided worksheet.

The Brixia scoring system divided the lungs into 6 regions. Each lung field zone is scored from a score of 0-3 based on lung abnormalities found on chest radiography. Score 0: without pulmonary abnormalities, score 1: the presence of interstitial infiltrates, score 2: presence of interstitial and alveolar infiltrates (dominantly interstitial), score 3: presence of interstitial and alveolar infiltrates (dominantly alveolar)[6] (Figure 1). The Brixia

score divided the severity scoring into 3, including: mild score (score < 5), moderate (score 6-11) and severe (score >12)[6].

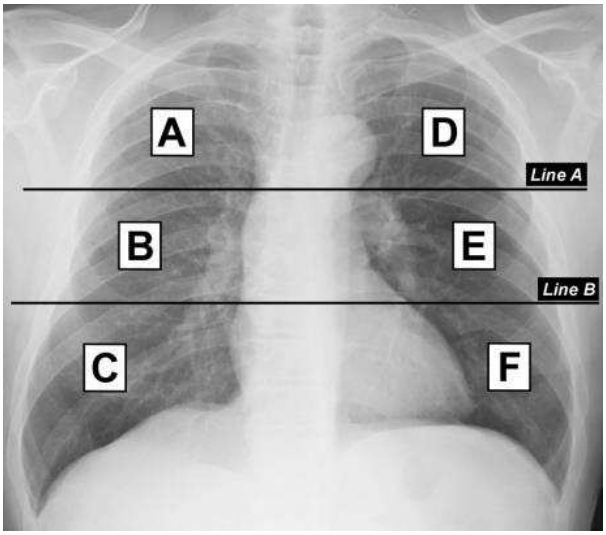

Figure 1. The Brixia scoring system divided the lungs into 6 regions

The RALE scoring system divided the lungs into 2 regions, left and right lung. Distribution of abnormality scores for each lung zone: a score of 0-4 is given for the extent of lung involvement in the form of areas of consolidation. Score 0: no lung involvement/area of consolidation, score 1 : < 25%, score 2 : 25 – 50%, score 3 : 50 – 75%, score 4 : > 75%[6]. The RALE score divided the severity scoring into 4, including: normal (score 0), mild score (score 1-2), moderate (score 3-5) and severe (score 6-8)[7] (Figure 2).

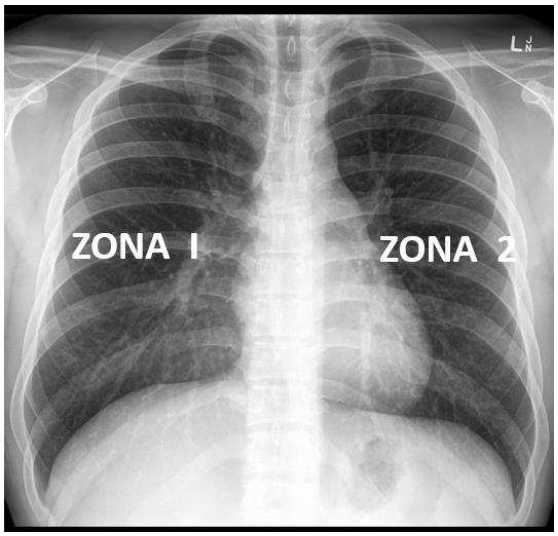

Figure 2. The RALE scoring system divided the lungs into 2 regions

Modified Dr. Soetomo hospital scoring system divided into 6 regions. Each lung field zone is scored from a score of 0-2 based on lung abnormalities found on plain chest radiography. Score 0: no lung involvement, score 1: found <50% lesion in the form of infiltrate / consolidation, score 2: found lesions > 50% in the form of infiltrates / consolidation. The Modified Dr. Soetomo Hospital scoring system divided the severity scoring into 3, including: mild score (score 1-4), moderate (score 5-8) and severe (score 9-12)[8] (Figure 3).

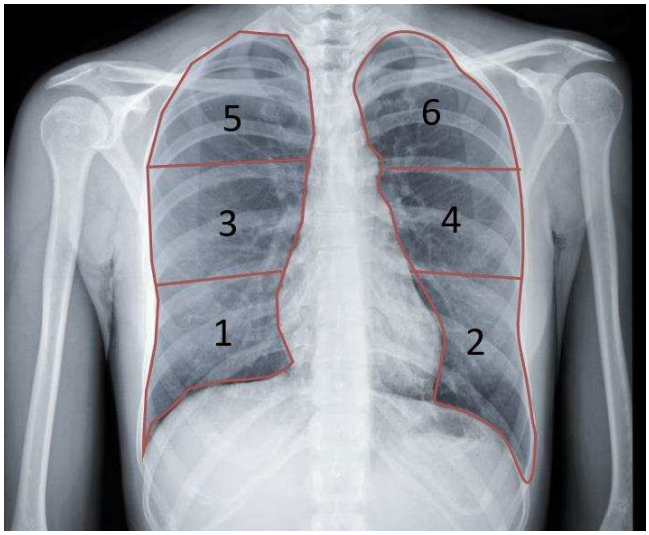

Figure 3. Modified Dr. Soetomo hospital scoring system divided into 6 regions.

3. Result

3.1 Patient Characteristic

Patient characteristics have been listed in Table 1. The age of our study ranged between 3-month-old and 91-year-old, with an average of 49. The number of male patients in our study was 323 subjects (53,5%), which was 42 subjects more than the number of female patients (46,5%).

Table 1. Patient Characteristic

Patient Characteristic	Number of patients (n= 604)
Age (year)	49 ± 14
Male	323
Female	281

3.2 Radiography Characteristics

Of the 604 patients, 573 patients showed abnormal chest X-ray as listed in Table 2. The distribution of lesion was mostly middle-lower zone predominant (214 of 604; 35,4%), peripheral bilateral (408 of 604; 67,5%). Other finding of chest X-Ray included pleural effusion in 31 patient (5,1%) and pulmonary nodules in 30 patients (4,9%). Abnormal chest X-ray showing mostly combination of alveolar and interstitial infiltrate (dominantly alveolar) (319 of 604; 52,8%).

Table 2. Radiography Characteristics

Radiography Characteristics	**Findings**
Normal Chest X-ray	31 (5,1 %)
Perihilar (Central)	90 (14,9 %)
Peripheral Unilateral	75 (12,4 %)
Peripheral Bilateral	408 (67,5 %)
Distribution of lesion	
Upper zone predominant	12 (1,9 %)
Middle zone predominant	46 (7,6%)
Lower zone predominant	150 (24,8%)
Upper-middle zone predominant	30 (4,9%)
Upper-lower zone predominant	4 (0,66%)
Middle-lower zone predominant	214 (35,4%)
Upper-middle-lower zone predominant	117 (19,3%)
Other Finding	
Pleural effusion	31 (5,1%)
Pulmonary nodules	30 (4,9%)
Lung Abnormality Features on Chest X-ray	
Interstitial infiltrate	120 (19,8%)
The combination of interstitial and alveolar infiltrate (dominantly interstitial)	134 (22,1%)
The combination of alveolar and interstitial infiltrate (dominantly alveolar)	319 (52,8%)

3.3 Severity degree of each scoring system

The average frequency of severity degree of Brixia, RALE, and Modified Dr. Soetomo Hospital scoring system were established in Table 3. There were 264 patients (43,7%) with severe disease, 229 (37,9%) with moderate disease, 107 (17,7%) with mild pneumonia, and 4 (0,6%) without abnormality per Brixia Score. According to the RALE score, there were 266 patients (44%) with moderate pneumonia, 253 (41,9%) with severe disease, 81 (13,4%) with mild pneumonia, and 4 (0,6%) with normal radiograph. Meanwhile, based on the Modified Dr. Soetomo Hospital scoring system, there were 263 patients (43,5%) with moderate pneumonia, 239 (39,6%) with severe pneumonia, 99 (16,4%) with mild pneumonia, and 3 (0,5%) with normal x-ray.

Table 3. The average frequency of COVID-19 severity degree scoring

	Brixia Score	**RALE Score**	**Modified Dr. Soetomo Hospital**
Normal	4	4	3
Mild pneumonia	107	81	99
Moderate pneumonia	229	266	263
Severe pneumonia	264	253	239

4. Discussion

Our samples consisted of patients aged between 3-month-old and 91-year-old, with an average of 49. Subjects aged above 50 constituted a significant proportion of 326 patients (54%) due to a higher expression of ACE-2 receptors, which was coded by the ACE-2 gene, along with other conventional factors, such as impaired immune response, organ dysfunction, or comorbidity that sums up to an elevated risk of mortality[9]. In the

elderly, the increased infection and complication risk from viral pneumonia are attributed to comorbidity factors. In addition, the decreased cellular and humoral immune function, respiratory muscle function, and respiratory tract protection by mucosa instigate the increased ability of the viral spread through the lower respiratory system, therefore, increasing the inflammatory reaction[10].

Moreover, the ACE-2 receptors were expressed more notably in men than women due to the influence of male sex hormones, making them more susceptible to SARS-CoV-2 infection. Another hypothesis stipulated that female carry the X-linked heterozygote allele, namely sex dimorphism, which increases the ability to forestall the SARS-CoV-2 infection development. This theory supports our findings of a higher men proportion in our samples (53,5%) compared to women (46,5%).

4.1 Radiography Characteristic

According to the British Society of Thoracic Imaging, 2019, a classic pattern of chest X-rays on probable COVID-19 cases is the finding of multiple opacity distributed predominantly at the peripheral and basal of both lungs. Lomoro et al. conducted a study on thirty-two patients with COVID-19 and demonstrated that consolidation was the most frequent finding (46,9%), distributed bilaterally (78,1%) with basal zone involvement (52%). Similarly, Jacobi et al. stated that the consolidation dispersed at the peripheral and basal zone was typical for COVID-19[11].

The characteristics of radiology images according to the Brixia Score consist of four categories: without lung abnormality, interstitial infiltrates, the combination of interstitial and alveolar infiltrates (dominantly interstitial), and the combination of alveolar and interstitial infiltrates (dominantly alveolar). The radiologic findings pattern depends on the course of viral infection and spread through the lower respiratory tract. The viruses usually invade the lower respiratory system and lung parenchyma following upper respiratory tract infection, mediated by aerosol particulate inhalation. The infection initiated from the mucosal epithelial cell cilia at the trachea and bronchus to the lower tract, widely destructing the cells involved in the organs, reflected as mucosal hyperemia, bronchitis, bronchiolitis, and loss of normal epithelial cells. The alveoli were filled by various numbers of neutrophils, mononuclear cells mixed with fibrins, and intra-alveolar edema fluid[10]. Mild-degree COVID-19 pneumonia presented as unilateral or bilateral interstitial infiltrates at the lower lobes of the lungs, which converted into alveolar infiltrates. After two weeks of disease, the lesions were gradually absorbed, marked by fibrosis appearance and parenchymal band[12].

In our study, the most recurring radiologic finding was the combination of alveolar and interstitial infiltrates (dominantly alveolar) in both lungs. Most of the patients were elderly and at the peak phase during hospitalization, hence, yielding a picture of dominantly alveolar infiltrates.

Based on the COVID-19 severity degree assessment from 604 subjects, we found that a major proportion of patients admitted at Dr. Soetomo Hospital were in moderate-severe pneumonia, requiring further treatment and management.

5. Conclusion

Based on the Brixia Score scoring system, the most common is a combination of interstitial and alveolar infiltrates (dominantly alveolar). The most common distribution of lesion sites is a combination of the mid-lower zone with peripheral and bilateral predominance.

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