

## RESEARCH ARTICLE

## Brixia Score for Predicting Mortality and Length of Stay in COVID-19 Confirmed Patients at the Hospital in Bandung

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### Abstract

On March 11, 2020, the World Health Organization declared the COVID-19 pandemic. This disease damages the lung and resulting mild to severe pneumonia. This study aimed to determine the value of the Brixia score for predicting mortality and length of stay of COVID-19 confirmed patients. The study design was case-control with secondary data from digital medical records of COVID-19 confirmed patients (December 2020 to February 2021). All patients' chest x-rays (CXR) were scored using the Brixia score. Logistic regression and the Spearman rank correlation test were used to identify mortality and length of stay predictors. There were 636 subjects included in this study, with the proportion of deceased patients (case group) being 20.3% (95% CI=17.33, 23.59%). Most CXR findings had signs of pneumonia (95.1%), including ground-glass opacities (GGOs) mixed with consolidation. The distribution of GGOs and consolidation were most frequent in the peripheral of survived patients (83.9%), while the deceased group had peripheral involvements mixed with medial (45.0%) and bilateral (22.2%). The mean Brixia score in the group of deceased patients was significantly higher than the group of survived patients (11.95 vs 6.73,  $p=0.00$ ). Brixia score had an OR of 1.14, 95% CI=1.07, 1.21 after adjusting by age, SpO<sub>2</sub> level, and comorbid. The chance of dying was higher than 50% if the Brixia score reached to score of 15 (probability=49%, 95% CI=41, 56%). However, the Brixia score has no significant correlation with length of stay ( $\rho=0.05$ ,  $p=0.24$ ). In conclusion, the CXR Brixia score can predict mortality, but it can not predict the length of stay of hospitalized COVID-19 confirmed patients.

**Keywords:** Brixia score, COVID-19, length of stay, mortality

### Introduction

On March 11, 2020, the World Health Organization declared the COVID-19 pandemic. The disease began in Wuhan, China, and spread to various parts, including Indonesia. The first cases in Indonesia were announced on March 2, 2020. On March 14, 2020, the Indonesian government declared the Coronavirus pandemic a national disaster.<sup>1</sup> Until January 31, 2021, reaching 175,095 active cases with 29,998 cases died.<sup>2</sup>

Clinical symptoms of COVID-19 patients can vary from asymptomatic, mild, moderate, and severe pneumonia symptoms and critical conditions such as multi-organ failure. The current diagnosis of COVID-19 is based on the results of the real-time reverse transcriptase-polymerase chain reaction (RT-PCR) examination. Still, this examination has limitations such as scarcity, time consumption, and various sensitivities (30–60%).<sup>3,4</sup>

This disease damages the lung and

resulting mild to severe pneumonia. Therefore, radiological examination becomes essential to support the diagnosis. A chest CT scan is a more sensitive radiological examination to assess lung abnormalities.<sup>4</sup> However, it has limitations from the hassle of becoming a serial examination tool because of increased risk of x-ray radiation and difficulties of transporting a patient to the CT-scan room. Lastly, this device was not easy to find in all health facilities in Indonesia. Thus, a chest x-ray (CXR) examination is still a reasonable method to detect the damage.

However, CXR examination is less sensitive than CT-scan in detecting lung abnormalities, especially in the early stages of the disease. Therefore, CXR can be a diagnostic tool for serial tests monitoring the development of lung abnormalities of COVID-19 patients in the current emergency.

Borghesi and Maroldi<sup>5</sup> in May 2020, introduced the Brixia score, a CXR assessment system to measure lung abnormalities in pneumonia due to COVID-19. Brixia scores assess

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pulmonary parenchymal abnormalities based on the degree of consolidation of lung tissue.

We found several studies that connect the association between Brixia score with a worse outcome to date. However, the probability (risk) of mortality and length of stay (LOS) predicted by the Brixia score was not found. Therefore, the purpose of the study was to analyze the value of the Brixia Score for predicting mortality and LOS of COVID-19 confirmed patients.

## Methods

A case-control study from 636 COVID-19 confirmed patients were presented to the Al Islam Hospital, Bandung, between December 2020–February 2021. The case was deceased patients, while control was those discharged from the hospital. Inclusion criteria were hospitalized COVID-19 patients confirmed by RT-PCR, over 17 years old, and performed a CXR when admitted to the hospital. Exclusion criteria were poor quality of CXR and patients with comorbid such as chronic lung diseases (e.g., pulmonary tuberculosis).

All CXR were reexamined to assess the presence of ground-glass opacities (GGOs) or consolidated lesions and their distribution pattern. In addition, the severity of the opacities was evaluated using the Brixia score by an experienced radiologist.

The CXR Brixia score of COVID-19 confirmed patients used in this study is the score developed by Borghesi and Maroldi.<sup>5</sup> There are two steps to make this score:

The first step, a posteroanterior or anteroposterior CXR, was divided into six zones (A, B, C, D, E, F), zones A, B, and C in the right zone D, E, and F in the left lobe. Zones A and D are the upper zones positioned above the inferior wall of the aortic arch. Zones B and E are the middle zones set below the upper zone and above the right inferior pulmonary vein (hilar structure). Zones C and F are the lower zones, positioned below the right inferior pulmonary vein (lung base).

Each zone is given a score in the second step based on the lung opacities found. For example, score 0 for no lung abnormalities, score one is an interstitial infiltrate, and score two is interstitial and alveolar infiltration (interstitial dominant). While score 3: there is interstitial and alveolar infiltration (alveolar dominant). Brixia score is

the result of accumulated scores from six lung zones.

Predictors of mortality and length of stay were identified among age, sex, comorbidities, and duration of illness before treatment. It is also based on measured SpO<sub>2</sub>, calcium level, sodium, potassium, and CXR findings (laterality, type of parenchymal opacity, lung zones involved, Brixia score). The analysis used was logistic regression and the Spearman rank correlation test.

This study was approved by the Health Research Ethics Committee of Al Islam Hospital Bandung, number 007/KEPPIN-RSAI/05/2021. The ethical aspect of this study is to respect the life of the research subject, confidentiality of the identity information of the research subject/patient, justice, and not cause harm to the research subject.

## Results

Of the 636 COVID-19 confirmed patients, 355 (55.8%) of them are male, with an age range of 17 to 88 years. The deceased patients was 129 people (20.3%, 95% CI=17.33, 23.59%), and survived patients were 507 people (79.7%, 95% CI=76.4, 82.67%).

The decease group did not have a significant proportion difference in sex ( $p=0.11$ ). However, male patients who died had a slightly higher percentage (27.4%) with a  $p$  value of 0.001 than patients who did not have comorbid (16.7%).

The Brixia score system was created as a semi-quantitative assessment of the severity and progression of lung abnormalities in COVID-19 confirmed patients.

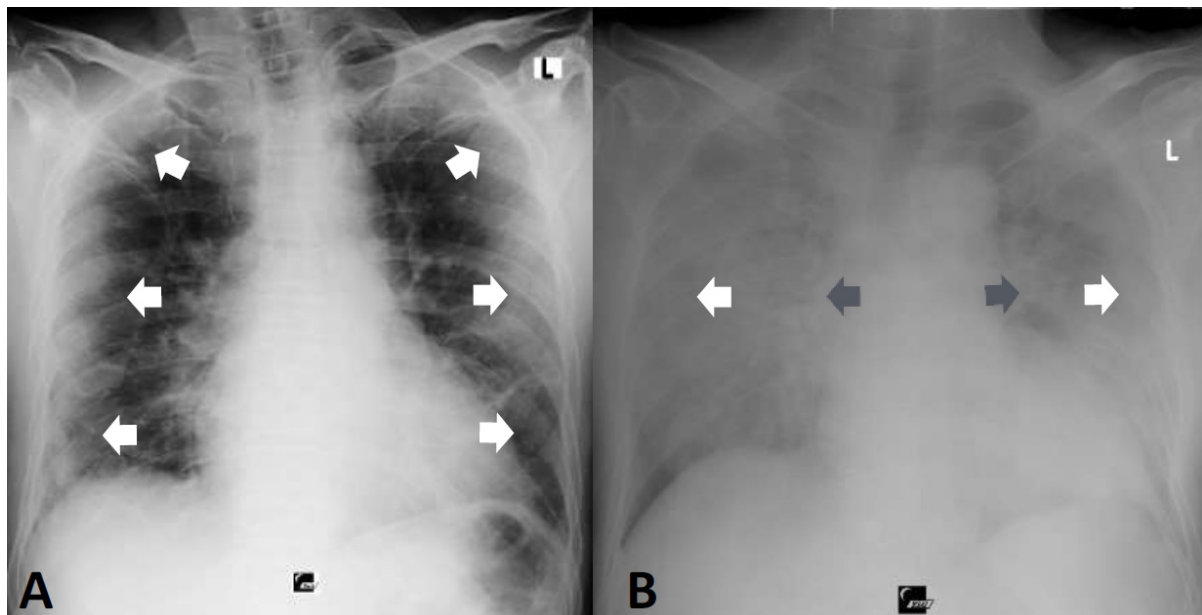
Radiologically, the CXR Brixia score describes the severity of pneumonia in COVID-19 confirmed patients. Most of them (92.1%) had pneumonia with interstitial lesions, i.e., ground-glass opacities mixed with consolidated lesions (Table 1 and Figure).

Table 2 shows that Brixia scores in the upper, middle, and lower lung zones are always higher in the deceased group than in the survival group. In addition, the Brixia score in the lower lung zone is higher than in the other zones, both in the decease and the survived group.

To analyze whether a CXR Brixia score could be a predictor of mortality, we included some variables that might affect mortality, as seen in Table 3.

**Table 1 Distribution of Pneumonia Lesions in COVID-19 Confirmed Patients**

Characteristics	Outcome			P
	Survived n (%)	Deceased n (%)	Total n (%)	
Distribution 1				0.002
None	31 (100)	0 (0)	31 (100)	
Peripheral	416 (83.9)	80 (16.1)	498 (100)	
Peripheral-medial	60 (55)	49 (45)	109 (100)	
Total	507 (79.7)	129 (20.3)	636 (100)	
Distribution 2				0.000
None	31 (100)	0 (0)	31 (100)	
Unilateral	35 (92.1)	3 (7.9)	38 (100)	
Bilateral	441 (77.8)	126 (22.2)	567 (100)	
Total	507 (79.7)	129 (20.3)	636 (100)	



**Figure Lung Abnormalities of CXR COVID-19 Patients at Al Islam Hospital Bandung**

Chest x-ray (CXR) findings show ground glass opacities (GGOs) admixed with consolidation. (A) Mostly peripheral (white arrow) and bilateral, Brixia score of 9. (B) Peripheral (white arrow)-medial (black arrow) and bilateral, Brixia score of 18

**Discussion**

In this study, 95.1% of CXR findings of COVID-19 confirmed patients had signs of pneumonia. The abnormalities on CXR were dominated by ground-glass opacities mixed with consolidated lesions. Several studies on radiological images of CXR and CT scans of COVID-19 patients showed similar results. In the study of Yoon et al.,<sup>6</sup> Smith et al.,<sup>7</sup> and Wong et al.,<sup>8</sup> radiological images of pneumonia is a ground glass opacities or mixed

with consolidated lesions.

Ground glass opacities are a slight increase in the opacity of lung tissue with the pattern of pulmonary blood vessels that are still visible.<sup>9,10</sup> Consolidation is a pathological process of filling the alveoli with fluid, pus, blood, cells, or other substances that can give opacities of lobar, diffuse or multifocal.<sup>11</sup>

SARS-CoV-2 attacks the lungs because the epithelial cells of alveolus type II express ACE-2 a lot.<sup>12</sup> ACE-2 is a functional receptor for SARS-

**Table 2 Distribution of Brixia Score in COVID-19 Confirmed Patients According to Lung Zone**

Brixia Score	Outcome	
	Survived	Deceased
Upper zones		
Median	0	2
IQR	0-2	1-4
Mean	0.92	2.63
SD	1.35	1.19
Skewness	1.6	0.29
Kurtosis	5.1	1.94
Middle zones		
Median	2	5
IQR	1-4	3-6
Mean	2.38	4.39
SD	2.02	1.82
Skewness	0.44	-0.89
Kurtosis	1.97	2.58
Lower zones		
Median	3	6
IQR	2-5	4-6
Mean	3.45	4.88
SD	1.88	1.53
Skewness	-0.13	-1.25
Kurtosis	1.91	3.51

CoV-2. Once SARS-CoV-2 binds to the epithelial cell of type II alveolus, it will continue its life cycle and penetrate the host cell through endocytosis or membrane fusion. It replicates inside the host cell nucleus and produces and releases new viral particles into the host cell's cytoplasm.<sup>13,14</sup>

Replicated viruses in alveolus epithelial cells cause inflammation of the alveolus wall. The alveolus wall thickens, thus giving a picture of increased pulmonary opacity. The process of widespread inflammation causes an exudation of fluid that fills the alveolus in both lung fields, causing the opacity of the lung field to increase, and pulmonary vascularization is no longer visible so that the CXR appears as a picture of consolidation.<sup>10,11,13</sup>

In Table 1, the distribution of lung abnormalities on the CXR most occurred on the peripherals in the survival group (83.9%). In the deceased group, most were peripheral mixed with medial lesions. The CXR image showed a significant difference in damage between the dead and the survived groups. The most dominant lung abnormalities in the deceased group were peripheral mix with medial lesions (45.0%) and bilateral (22.2%)

In Table 2, the mean Brixia score is higher in the lung's lower zone than in other zones in both groups. Similarly, the mean Brixia score was higher in all lung zones in the deceased

**Table 3 Frequency Distribution of Observation Variables**

Observation Variables	Outcome	
	Survived	Deceased
Age		
Median	54	62
IQR	45-63	57-69
Mean	53.13	62.61
SD	13.94	11.15
Skewness	-0.27	-0.39
Kurtosis	2.67	3.56
Length of stay		
Median	7	4
IQR	6-10	3-6
Mean	8.11	5.11
SD	3.01	3.66
Skewness	1.07	1.4
Kurtosis	4.27	4.87
Duration of illness before treatment		
Median	7	4
IQR	6-10	3-6
Mean	8.11	5.11
SD	3.01	3.66
Skewness	1.07	1.4
Kurtosis	4.27	4.87
SpO <sub>2</sub> level		
Median	7	4
IQR	6-10	3-6
Mean	8.11	5.11
SD	3.01	3.66
Skewness	1.07	1.4
Kurtosis	4.27	4.87
Brixia score		
Median	7	4
IQR	6-10	3-6
Mean	8.11	5.11
SD	3.01	3.66
Skewness	1.07	1.4
Kurtosis	4.27	4.87
Calcium		
Median	7	4
IQR	6-10	3-6
Mean	8.11	5.11
SD	3.01	3.66
Skewness	1.07	1.4
Kurtosis	4.27	4.87
Sodium		
Median	7	4
IQR	6-10	3-6
Mean	8.11	5.11
SD	3.01	3.66
Skewness	1.07	1.4
Kurtosis	4.27	4.87
Potassium		
Median	7	4
IQR	6-10	3-6
Mean	8.11	5.11
SD	3.01	3.66
Skewness	1.07	1.4
Kurtosis	4.27	4.87
INR		
Median	48	50
IQR	40-56	40-60
Mean	45.74	48.83
SD	15.37	16.98
Skewness	-0.77	-0.35
Kurtosis	3.68	2.78

**Table 4 Influencing Factors of Confirmed COVID-19 Mortality**

Deceased	OR	95% CI		p (z)	p Chi-square	Pseudo R Square
Brixia scores	1.14	1.07	1.21	0.00	0.00	0.32
Age	1.04	1.03	1.07	0.00		
Duration of illness before treatment	0.98	0.94	1.04	0.61		
SpO <sub>2</sub> level	0.0002	0.00	0.003	0.00		
Comorbid	1.61	0.99	2.61	0.05		
Constant	7.15	0.37	138.41	0.19		

group than in the survived group. It means that the Brixia score describes the severity of lung tissue damage that has the potential to increase mortality. Autopsy studies of patients who had died from severe SARS-CoV-2 infection revealed alveolar wall injuries and diffuse alveolar damage consistent with ARDS. However, compared to classical ARDS, autopsy studies also showed a higher presence of thrombus in pulmonary capillaries, suggesting a more significant pathogenic role of thrombotic vasculopathy and microangiopathy in COVID-19-related ARDS. Studies collectively show that thromboembolic occurs more frequently and is associated with higher mortality in COVID-19 confirmed patients.<sup>15</sup>

The mortality rate was 129 people (20.3%), with the subjects' age range of 17–88 years. It is more significant when compared to a meta-analysis conducted by Macedo et al.<sup>16</sup> on 33 articles with the subject of 13,398 COVID-19 patients, the most subjects (45%) from China. The percentage of patient mortality was 11.5%, with the subject's age range from less than one year to 107 years.

In Table 3, the median of LOS of COVID-19 confirmed patients of the survived group was seven days, and the median of LOS of the deceased group was four days. The mean duration of illness before treatment in the survived group was 11.36 days and in the deceased group was 11.35 days. In the times of pandemic that it becomes essential to predict the LOS of COVID-19 confirmed patients to ensure the availability of sufficient bed capacity without the need to reduce care for patients with other diseases.<sup>17</sup>

From Table 3, variables of age, LOS, duration of illness before treatment, SpO<sub>2</sub> levels, calcium, sodium, potassium, and INR are not distributed normally based on differences in mean, median, standard deviation, skewness, and kurtosis. The normal distribution assumptions are only

for Brixia scores. The mean Brixia score in the deceased group was 11.95, more significant than the survived group (6.73).

The median age of the deceased group was older than the survived group, but LOS (four days) was three days shorter than the survived group (seven days). There was no difference in the median duration of illness before treatment between the survived group (13 days) and the deceased group (13 days). The median of SpO<sub>2</sub> levels in the deceased group was lower (83%) than in the survived group (94%). There was no significant difference in the median of blood electrolytes in the deceased group and survived group and INR.

The mean Brixia score in the deceased group (11.95) was statistically higher (5.22 95% CI=4.34,

**Table 5 Possible Mortality of Confirmed COVID-19 Patients based on Brixia Score**

Brixia Score CXR	Possibility of Death	95% CI	
0	0.03	0.01	0.04
1	0.03	0.02	0.05
2	0.04	0.02	0.06
3	0.05	0.03	0
4	0.06	0.04	0.09
5	0.08	0.05	0.11
6	0.1	0.07	0.13
7	0.12	0.09	0.16
8	0.15	0.12	0.19
9	0.19	0.15	0.22
10	0.22	0.19	0.26
11	0.27	0.23	0.31
12	0.32	0.27	0.37
13	0.37	0.32	0.43
14	0.43	0.36	0.49
15	0.49	0.41	0.56
16	0.55	0.47	0.63
17	0.61	0.52	0.69
18	0.66	0.57	0.75

6.1) compared to the survived group (6.73) with a p value of 0.00 (t test). This difference has not shown a possible relationship between Brixia scores with mortality, so it needs to be continued into the logistic regression analysis in Table 4.

In Table 4, it is seen that all the variables that are likely to affect mortality, except comorbid, are all continuous variables. The variable of the duration of illness before treatment is further excluded due to a p value of 0.61. Based on the measure of association used (odds ratio, OR), the risk factors that play the most role in mortality are comorbid with OR=1.61 (95% CI=0.99, 2.61), followed by a CXR Brixia score with OR=1.14 (95% CI=1.07, 1.21). It means that the higher the value of these variables, the greater the mortality risk. Conversely, OR of SpO<sub>2</sub> levels are below one (OR=0.0002, 95% CI=0.00, 0.003), which means the higher the level of SpO<sub>2</sub>, the lower the risk of mortality.

A chi-square p value of 0.00 indicates that Brixia scores, age, SpO<sub>2</sub>, and comorbid levels are responsible for the 32% mortality variable (pseudo r square). Next, we analyzed OR crude and OR adjusted to see any changes in or initial Brixia score of treatment to find out the presence of interaction variables or confounds with multiple logistic regression.

There was no difference in OR crude CXR Brixia score compared to OR adjusted with the variable of age, SpO<sub>2</sub>, and comorbid levels. Therefore, the CXR Brixia score is used to predict mortality. Brixia score prediction analysis of a score of 0 is analyzed to see the possibility of mortality in Table 5. The higher the Brixia score will increase the chances of mortality. The probability of mortality is higher than survival on a Brixia score  $\geq 15$  (49%, 95% CI=41.56% chance).

The study results conducted by Setiawati et al.,<sup>18</sup> Maroldi et al.,<sup>19</sup> and Munirathnam et al.<sup>20</sup> showed that the Brixia score correlated significantly with the severity of COVID-19 patients clinically. Maroldi et al.<sup>19</sup> and Munirathnam et al.<sup>20</sup> also found that Brixia scores were external predictors of hospitalized COVID-19 patients, whether surviving or dying.

According to Borghesi et al.,<sup>21</sup> Brixia's high score plus at least one other predictive factor has an increased risk of death while in treatment. In his research, the predictive factors are age and immunosuppressant therapy.

The correlation between Brixia scores with the LOS is calculated statistically, and because the

data is not distributed normally, the Spearman rank correlation test ( $\rho=0.05$ ,  $p=0.24$ ) is used. Unfortunately, there was no significant correlation between Brixia scores and LOS, so Brixia scores cannot be predictors for LOS.

The drawback of this study is that only one radiologist assessed diseased severity based on the Brixia score

## Conclusion

The CXR Brixia score can predict mortality, but it can not predict the length of stay of hospitalized COVID-19 confirmed patients.

## Conflict of Interest

The authors do not declare.

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