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THE BRIXIA CHEST X RAY SEVERITY SCORE IN ADULT PATIENTS WITH SYMPTOMATIC COVID-19 INFECTION: A USEFUL GUIDE TO MANAGEMENT

Running title: Chest X Ray findings and outcome in COVID-19

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ABSTRACT:
COVID-19 is a highly contagious viral illness with a wide spectrum of clinical manifestations ranging from asymptomatic or mild cold like symptoms to a devastating and often fatal respiratory illness. The elderly and those with underlying morbidity are the groups most often, but certainly not exclusively, associated with death from respiratory pathology. COVID-19 respiratory illness usually manifests clinically as pneumonia with predominant imaging findings of an atypical or organized pneumonia. Chest radiography (CXR) helps to assess the progress of the disease. The BRIXIA score based on radiological appearance may be used to determine the severity and clinical outcome of a patient with COVID-19. The aim of this study was to assess the relationship between the BRIXIA score and the clinical outcome of positive COVID-19 patients at Port Moresby General Hospital (PMGH) in Papua New Guinea (PNG). In this descriptive retrospective study conducted at the Radiology Department of the PMGH the records of 129 Polymerise Chain Reaction (PCR) confirmed patients admitted to PMGH between September and December 2021 were examined. The patients were grouped into mild, moderate or severe categories depending on clinical features at the time of diagnosis. There were 89 (69%) males and 40 (31%) females. The mean (SD) age was 52 (12) years, and the median (IQR) was 53 (44-60). Their admission CXRs were given a Brixia score. Mean (SD) Brixia scores for mild (n=24), moderate (n=67) and severe (n=38) were 4.5 (2.5), 8.9 (2.7) and 12.5 (3.5) respectively. The Brixia score was significantly related to the clinical severity, F 55.49, p <0.001. Twenty seven (77%) of the 35 patients who died had comorbidities of whom 21 (78%) were in the clinically severe group. A Brixia score of 9 or more was closely associated with death, p = 0.001, Odds Ratio with 95% Confidence interval (0R) of 3.9 (1.7-9.6). The Brixia CXR severity score is a useful tool in assessing clinical severity and prognosis in patients with COVID-19.

Key Words: Chest X Ray, Brixia Score, Clinical Severity, Outcome

INTRODUCTION:

Corona virus disease 2019 (COVID-19) is a severe acute respiratory illness caused by SARS-CoV-2, a novel virus belonging to the family Coronaviridae. It was first discovered in December 2019 in Wuhan City, Hubei province in China. It is a highly contagious disease that rapidly spread throughout the world leading the World Health Organization (WHO) to declare a pandemic on March 11, 2020 [1]. The clinical spectrum is wide, with the younger population often asymptomatic or mildly affected with flu like symptoms, but with substantial mortality in the elderly and those with underlying morbidities such as chronic obstructive airways disease and diabetes. A debilitating post viral illness was recognised early in the pandemic [2]. Respiratory pathology remains the main cause of mortality [3].

Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) on nasopharyngeal secretions is the gold standard in diagnosing COVID-19 [4]. Chest x-ray (CXR) is usually of limited value in the diagnosis of early stages of COVID pneumonia when compared to computed tomography (CT) but is very helpful in intermediate to advanced stages of COVID-19 as well as for follow-up. Serial CXRs have been shown to be almost as valuable as CT [5, 6]

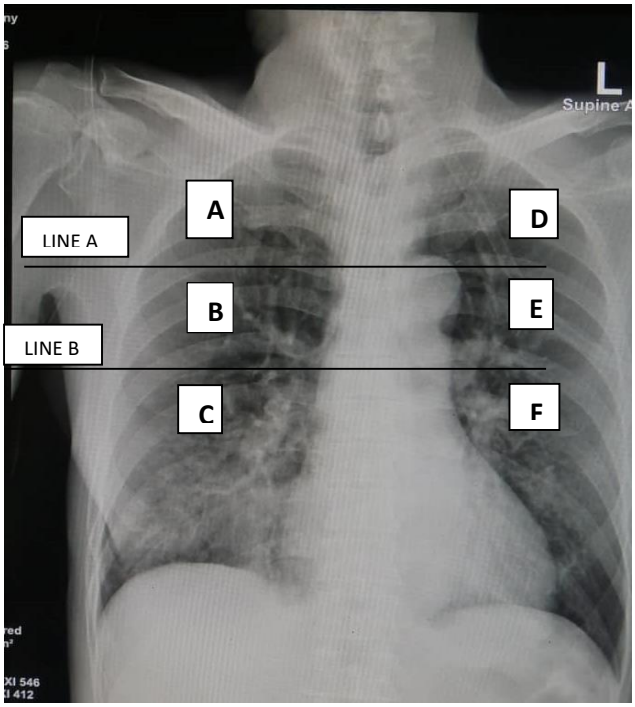
COVID-19 is transmitted via respiratory droplets and as aerosols. In the lungs the virus induces an inflammatory reaction with damage to type 1 and 2 pneumocytes resulting in alveolar collapse and consolidation [7]. The pathophysiological changes within the lung parenchyma are responsible for the radiological features seen on CXR and CT chest as interstitial opacities, ground glass opacities or consolidation.

CXR may be normal in early or mild disease. As the disease progresses, several studies have shown consolidation as the most common finding followed by ground-glass opacities and interstitial opacities. Abnormalities at chest radiography have a peripheral and lower zone distribution with bilateral involvement. Pleural effusion is uncommon [8-10].

Different scoring methods have been used to assess CXR severity of COVID-19, including the Radiographic Assessment of Lung Edema Score (RALES), modified RALES and Brixia score [11, 12].

In calculating the Brixia score horizontal lines drawn at the level of the inferior wall of the aortic arc and a second one above the inferior wall of the right inferior pulmonary vein on frontal projection delineates 6 zones- the right and left upper, middle and lower zones (Figure 1).

Figure 1. The Brixia Score Lung Areas



A score (from 0 to 3) is assigned to each zone based on the lung abnormalities detected as follows:

Score 0: no lung abnormalities;
Score 1: interstitial infiltrates;
Score 2: interstitial and alveolar infiltrates (interstitial predominance);
Score 3: interstitial and alveolar infiltrates (alveolar predominance).

The scores of the six lung zones are added to obtain an overall "CXR SCORE" ranging from 0 to 18. The Brixia score was shown to be related to the likelihood of mortality in 2000 [12].

Our study aimed to assess the use of the Brixia score in our resource restrained setting during a period of high demand on medical imaging services. Ethics approval was given by the School of Medicine and Health Sciences Research and Ethics Committee and permission to carry out the study was granted by the PMGH Administration.

METHODOLOGY:

This descriptive retrospective study was conducted at PMGH, between September and December 2021. Adult patients who tested positive for COVID-19 and had a CXR performed were the target population. Pregnant women and adolescents were excluded.

The CXRs were reviewed with 3 consultant Radiologists. The lung involvement, zonal

predominance and the type of opacity present was identified and the Brixia score for each CXR was calculated and entered into an Excel spread sheet. Hospital record charts were retrieved from the Medical Units and patients' were classified as mild, moderate or severely ill based on their clinical features at the time of the CXR. Patient demographics and underlying morbidities were recorded.

Statistical analysis:

The data was analyzed using the Statistical Package for Social Sciences (SPSS) software version 22. Means and standard deviation (SD) were generated for normally distributed data. Frequencies and percentages were calculated for binary data. ANOVA compared the Brixia scores for each of the clinical groups. The chi-square test and Odds Ratios with 95% confidence limits were used to assess the relationship between Brixia score and outcome using Open Epi.

RESULTS:

PMGH Radiology department registered 363 CXRs for adult PCR positive COVID-19 patients from September 2021 to December 2021. Eighty eight were repeat CXRs to assess the disease progress and 46 cases were not on the Picture Archiving and Communication System (PACS). 229 CXRs were reviewed to determine the common radiological features of COVID-19 (Figure 2).

Figure 2: Recruitment of study cases to determine outcome.

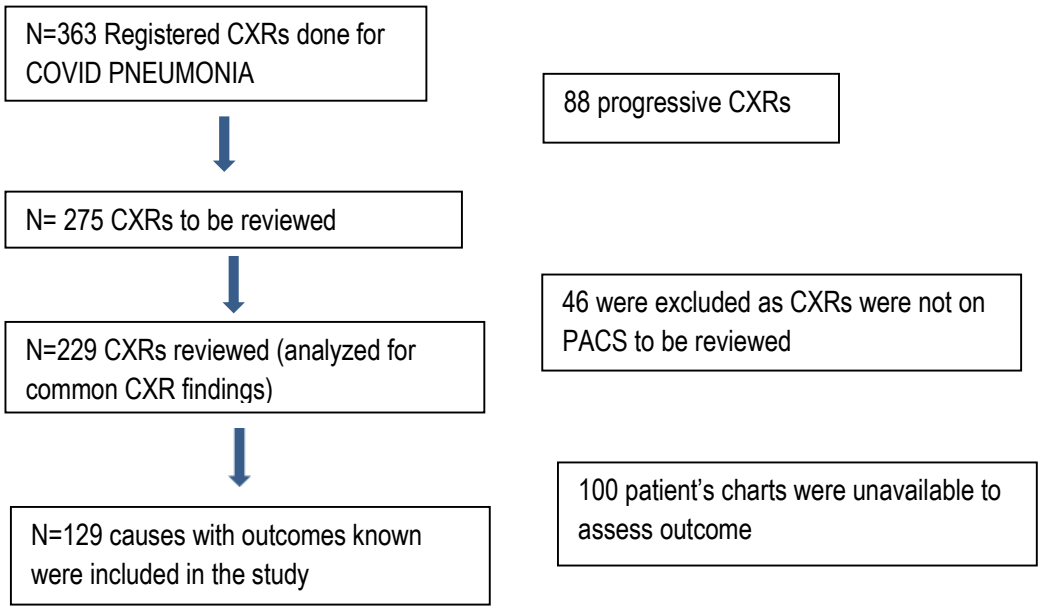


Table 1. Demographic characteristics of 129 COVID-19 patients

Age Years	**Male N (%)**	**Female N (%)**	**Total**
24-34	9 (11.6)	2 (2.5)	11 (14.2)
35-44	15 (19.4)	7 (9)	22 (28.4)
45-54	28 (36.1)	10 (12.9)	38 (49)
55-64	21 (27.1)	16 (20.6)	37 (47.7)
65-74	13 (16.7)	5 (6.4)	18 (23.2)
75-84	3 (3.8)	0	3 (3.8)
Total	89 (69)	40 (31)	129 (100)
≥55	37(41.6)	21 (52.5)	58 (45)
<55	52 (58.4)	19 (47.5)	71 (55)

Table 2: CXR Radiological findings

Radiological findings	Total (n=229)
Affected lung	
Right lung involvement	3 (1.3%)
Left lung involvement	10 (4.4%)
Both lung involvement	212 (93.2%)
Distribution	
Perihilar	23 (10.0%)
Peripheral	108 (47.6%)
Neither	94 (41.0%)
Zone predominance	
Upper zone	0
Mid zone	19 (8.3%)
Lower zone	115 (50.2%)
Non-zonal	91 (39.7%)
CXR opacities	
Ground glass	78 (34.3%)
Consolidation	144 (62.8%)
Interstitial opacities	142 (62.0%)
Pleural effusion	2 (0.9%)
Pneumothorax	1 (0.4%)
Fibrosis	2 (0.9%)
Pulmonary nodules	4 (1.7%)

Table 3: Brixia score and clinical diagnosis Range, Mean (SD)

COVID-19 Severity	Frequency	Brixia score range. Mean (SD)
Mild	24 (18.60%)	Range 0-8, mean 4.5 (2.5)
Moderate	67 (51.9%)	Range 4-16, mean 8.9 (2.7)
Severe	38 (29.5%)	Range 6-18, mean 12.5 (3.5)

Medical case records were retrieved for 129 patients. There were 89 males (69%) and 40 females (31%). For all the 129 patients, the mean age was 52.3 (SD: 12.0) with age range 24-84 years; the median (Interquartile Range: IQR) was 53.0 (44 - 60) years. Table 1 shows the demographic characteristics of all the patients.

Table 2 shows the radiological findings from the initial 229 CXRs reviewed. Both lungs were affected in 214 (93.3%). The opacities were distributed in the peripheral region of the lungs in 108 (47.6%) patients and in the lower zones in 115 (50.2%) patients. Consolidation was present in 144 (62.8%), interstitial opacities in 142 (62.0%) and ground glass opacities in 78 (34.3%).

Table 3 shows the Brixia scores in the mild, moderate and severe clinical groups. There were highly significant differences (ANOVA F = 55.49 p=<0.001) as illustrated in figure 3.

Figure 3: Brixia score and COVID-19 severity

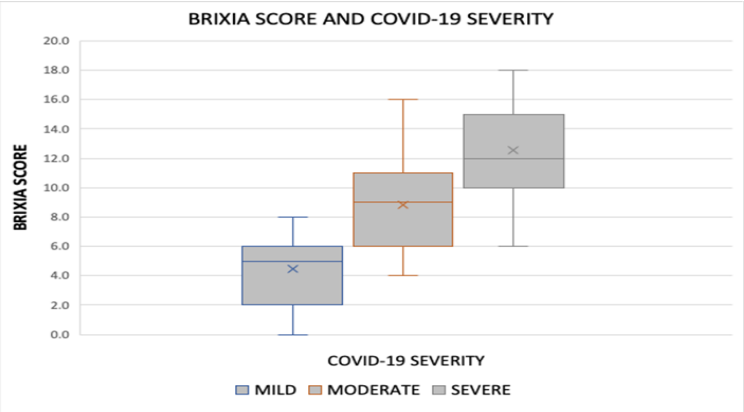


Table 4 shows the outcome in the clinical groups. All patients who died in the clinically mild or moderate groups had underlying comorbidities as did 21 (72%) of the 29 with severe disease at presentation.

Table 4: Outcome of COVID-19 patients

Clinical Severity	Discharged N (%)	Died N (%)
Mild	21 (16)	3 (2)
Moderate	64 (50)	3 (2)
Severe	9 (7)	29 (22)
Total	94 (73)	35 (27)

Table 5 shows the outcome of those with a Brixia score of ≥ 9 and those with a score of <9. Twenty six (39%) of the 66 patients with a score ≥9 died compared with 9 (14%) of 63 who had lower scores. (p=0.001, OR 3.9 (1.7-9.6). There were no differences between males and females in outcome in the two Brixia score groups.

Table 5: Brixia score ≥9 and clinical outcome

Brixia score	**Patients N (%)**	**Deaths N (%)**	**Survived N (%)**
Brixia score ≥9	66	26 (39)	40 (61)
Males	41 (62)	16 (39)	35 (61)
Females	25 (38)	10 (40)	17 (60)
Brixia score <9	63	9 (14)	54 (86)
Males	47 (75)	7 (15)	40 (85)
Females	16 (25)	2 (13)	14 (87)

DISCUSSION:

The COVID-19 pandemic presented many challenges for health services including in the areas of diagnosis and appropriate management. Management decisions can be helped by the availability of accurate and simple prognostic indicators including robust chest radiography algorithms.

There was a male preponderance in our study- consistent with findings from a systematic review and meta-analysis of data from other countries [13]. The review found high frequency of smoking and alcohol consumption in men to be a factor

The most common CXR opacities detected were consolidation 144 (62.8%), followed by interstitial opacities 142 (62.0%) and Ground Glass Opacities 78 (34.3%) consistent with reports from other countries [8-10].

The Brixia scores on the admission CXRs were significantly aligned with the Clinical severity scores with mean (SD) scores for mild, moderate and severe groups of 4.5 (2.5), 8.9 (2.7) and 12.5 (3.5) respectively ($p<0.001$).

The Brixia score was significantly associated with outcome. Twenty six (39%) of 66 patients with a score of ≥9 died compared with 9/61 (15%) patients with a score of <9 ($p=0.003$, OR 3.9 (1.7-9.6). Studies from other countries have reported similar results. In a study of 953 patients in the early months of the pandemic from Lombardy in Italy Brixia scores were significantly higher in patients who died than in survivors $p<0.001$ [14]. In a study from a tertiary hospital in India a Brixia score more than 12 was associated with increased mortality ($p= 0.03$) [15]. Other studies have used combined scoring systems (eg RALES) with the Brixia score or the Brixia score with other risk factors to improve predictive value [16-17].

Our study has a number of limitations. There were no CXRs from non COVID-19 patients with which to compare the Brixia scores performance in predicting outcome in infected patients. The sample size was small, - mainly the result of delay in setting up an adequately documented patient registration system. However, the sample size was sufficient to demonstrate clear associations between Brixia score, severity and outcome. In spite of these limitations the study clearly demonstrated the close association of Brixia score with clinical severity and outcome.

CONCLUSION:

In a resource strained country where CT is limited, CXR is the main radiological modality of choice when dealing with COVID-19. An understanding of the typical CXR features of COVID-19 will aid in diagnosis and monitoring the disease. Our study findings, supported by data from other parts of the world, confirm that the Brixia score is a useful predictor of likely outcome in COVID-19 patients presenting with respiratory signs and can be used to assist clinicians in their management plans.

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