Chest X-Ray Severity Index as a Predictor of Requiring Invasive Positive Pressure Ventilation in COVID-19 Positive Patients

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ABSTRACT

The aim of this study is to see the role of the chest X-ray severity index (Brixia score) as a predictor of requiring invasive positive pressure ventilation in COVID-19-positive patients. This descriptive cross-sectional prospective study were carried out in the Department of Pulmonology and Radiology, Mayo Hospital, Lahore. The data were collected from 1st May to 30th July 2020 from 60 consecutive COVID-19 positive patients. Analysis was conducted using each patient's age, gender, clinical presentation, and the report of CXR containing the most elevated score. The mean age of the study participants was 59.43±11.27, and 81.7% of patients had positive Brixia scores (≥8). Brixia score had high sensitivity (93.886) and specificity (90.91%) to predict the need for IPPV using chest X-rays. It showed excellent predictive power, having a high numerical AUC (0.870) and a statistically significant p-value (<0.0001). High Brixia score conferred a high risk of the need for invasive positive pressure ventilation due to COVID-19.

Key Words: *Chest X-ray, Brixia score, COVID-19, Invasive positive pressure ventilation.*

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In the beginning of COVID-19 pandemic, healthcare workers have been facing issues in distinguishing and depicting the clinical characteristics, course, and treatment of the patients. Nucleic acid assessment of samples from the respiratory tract was required for the confirmation of the infection, but clinical evaluation and diagnosis were made on signs and symptoms, exposures to the infective agents, and chest imaging. Currently, healthcare facilities are utilising real-time reverse--transcription–polymerase-chain-reaction (RT-PCR) assay for COVID-19 detection. Even though RT-PCR stays the gold standard to build a confirmed diagnosis of COVID-19,[1] prompt diagnosis of infected patients is limited because of the elevated false negative rate and inaccessibility of RT-PCR assay at the start of the pandemic.[2,3] Chest radiography (CXR) is conducted more broadly and promptly than a CT scan for the treatment of COVID-19, but there is not enough information available yet on its clinical utilisation.

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Henceforth, a new chest X-ray (CXR) scoring framework for evaluating and monitoring the severity of lung anomalies in patients with COVID-19 was introduced to enhance the risk stratification for the patients.[4] Eighteen point severity scale is used to grade lung abnormalities caused by COVID-9 in this CXR scoring system (named the Brixia score).[4] A study reported that the mean Brixia score in recovered patients was statistically lower [(7.0 (4.0–10.0)] as compared to patients who died [11.0 (9–13.0, p-value <0.0001].[5]

The current study aimed to determine the importance of the chest X-ray severity index in determining the requirement of invasive positive pressure ventilation (IPPV) in COVID-19-positive patients. If found high, then it can be used as a tool for the prediction of requiring invasive positive pressure ventilation in COVID-19 positive patients.

The current prospective study was conducted from May 2020 to July 2020 at the Departments of Radiology and Pulmonology, Mayo Hospital, Lahore. After the approval of the proposal, all consecutive positive patients, of any age and gender with initial signs or symptoms suggestive of COVID 19 infection were included. Patients with structural lung diseases, heart failure, chronic kidney diseases (CKD), and chronic liver diseases (CLD) were excluded. CR (computerised Radiography) was utilised to perform portable bedside CXR (chest X-rays).

Table I: Predictive accuracy of Brixia score in determining the need for IPPV.

	Need of IPPV			
	Yes	**No**	**Total**	**p-value**
Positive *Brixia* score n (%)				
Yes	46(93.9)	3(6.12)	49(81.7)	<0.0001
No	1(9.09)	10(90.9)	11(18.3)	
Total	47	13	60	
	Parameters	**Estimate (%)**		**95% CI**
Predictive accuracy	Sensitivity	93.88		(83.48, 97.9)
	Specificity	90.91		(62.26, 98.38)
	PPV	97.87		(88.89, 99.62)
	NPV	76.92		(49.74, 91.82)
	Diagnostic Accuracy	93.33		(84.07, 97.38)

*IPPV = Invasive positive pressure ventilation; % = Percentage; CI = Confidence interval; PPV = Positive predictive value; NPV = Negative predictive value; * = Chi square test was used to determine p-value and p <0.05 is considered significant.*

To standardise patients' ventilatory needs, the standardised invasive ventilation criteria were followed including, impending ventilatory failure, apnea, and acute ventilatory failure with ph <7.25 and $PaCO_2$ ≥50 mmHg, with or without clinical signs. Brixia score was calculated after performing CXR.

Six zones of the lungs were allocated on frontal chest projection in the first step. Technical limitations to locate some anatomical landmarks included; suboptimal inspiration effort of the patient, suboptimal position in bed, and movement blur. In such cases, each lung was divided into three equal zones. A score (from 0 for no lung abnormalities to 3 for interstitial and alveolar infiltrates) was given to each lung zone depending on the abnormalities of the lungs seen on frontal chest projection in the second step. CXR SCORE ranging from 0 to 18 was then obtained by adding the scores of six lung zones. Brixia score greater than or equal to eight was taken as a positive and predictive score.

Invasive positive pressure ventilation (IPPV) were measured as primary outcomes. Brixia score was the independent variable. The data was entered and managed in SPSS version 24. Mean and standard deviation was used to demonstrate the quantitative data. Findings of IPPV were cross-tabulated and hence, diagnostic accuracy including sensitivity, specificity, positive predicted value (PPV), and negative predicted value (NPV) was computed. Additionally, the area under the receiver operating characteristics (ROC) curve was estimated to predict the need for IPPV in COVID-19 patients. A p-value <0.05 was the criterion for the significance of the results.

Out of 60 included patients, the mean age of the study participants was 59.43±11.27 years, 48(80%) were males and 12 (20%) were females. The most common symptom was fever with cough (58.3%), followed by fever with shortness of breath (SOB) (26.7%), loss of taste (10.0%), loss of smell (3.3%), and fever with chills (1.7%). The baseline mean Brixia score in patients was 9.90±2.65. Table I demonstrates the cross-tabulation of positive Brixia score and the need for IPPV. Brixia score was positive in 49 (81.7%) patients among whom 46 (93.9%) needed IPPV while only 1(9.09%) patient with a negative Brixia score needed IPPV (p-value <0.0001). The sensitivity, specificity, PPV, NPV, and diagnostic accuracy for the need of IPPV for Brixia score prediction rule is also presented in Table I. Brixia score had high sensitivity (93.88%) and specificity (90.91%) to predict the need for IPPV using chest X-rays.

The ROC curve was used to predict the need for IPPV in COVID-19 using the Brixia scoring system. Brixia score showed excellent predictive power, having a high numerical AUC (0.870; 95% CI, 0.741-0.998) and statistically significant p-value (<0.0001).

The evolving epidemic puts extraordinary pressure on healthcare frameworks, generating the requirement to balance medical equipment and interventions. The need for more diagnostic and predic approaches has been highlighted during the ongoing viral epidemic for enhancing patient care and treatment, more importantly, if access to essential care resources is confined or crushed. In May 2020, Borghe *et al.* established the Brixia scoring system, a CXR test program to measure lung dysfunction in COVID-19 pneumonia.[5]

The capability of the Brixia scoring system in predicting the need for invasive positive pressure ventilation in COVID-19 patients was analysed in the present study. A significant proportion of patients (81.7%) reported a positive initial chest X-ray, and a considerable number of patients (78.3%) underwent ICU admission with the need for IPPV (p<0.0001). In this patient population, the chest X-ray severity index calculated as the Brixia score proved to be a good model for predicting the requirement of IPPV (AUC=0.87). Very few studies have been conducted to find out the importance of CXR to assess the need for IPPV in COVID-19 patients, but no study used the Brixia score for this purpose. In a study done by Toussie *et al.*, it was found that the requirement for intubation in COVID-19 patients was significantly dependent on a lung zone severity score on the initial chest X-ray (p=0.002).[6]

The observational nature of the present prospective study is one of the no limitations as it is unable to gauge change over time. Another limitation was the incredibly small sample size. Moreover, differences in the time span of signs and symptoms and infection upon presentation to the hospital caused variation in diagnostic confirmation on initial chest X-ray.

In conclusion, this study showed that a high Brixia score conferred a high risk of the need for invasive positive pressure ventilation due to COVID-19. While the findings of this study provide the validation of the Brixia score as a prognostic tool for the need for invasive positive pressure ventilation, more studies with larger sample sizes are required to establish the findings.

COMPETING INTEREST:
The authors declared no competing interest.

AUTHORS' CONTRIBUTION:
MAH, MSS: Substantial contribution to the conception and data collection of the study.
MSS, SA: Analysed and interpreted the data.
MM, AWK, MFN: Drafting and editing process of the manuscript. Moreover, they critically revise the document.
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