Initial Chest X-ray scoring in the prediction of COVID-19 patients' outcome in the United Arab Emirates

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Abstract:

Background: The radiological scoring of severity and progression of lung abnormalities is of great value for clinicians to define the clinical management of COVID-19 patients.

Objectives: The purpose of this study is to implement the Brixia scoring tool to assess the pattern of lung involvement in patients with COVID-19 to help predict the severity of their clinical outcome, where the clinical outcome correlates to outpatient, inpatient and/or ICU admission.

Patients and Methods: We conducted a case series study at the Sheikh Khalifa Medical City Ajman (SKMCA), United Arab Emirates from 14 March to 30 October 2020. Patients' medical records were reviewed and followed up from the time of diagnosis until discharge and/or death. The patients were included based on the following criteria: Confirmed COVID-19 infection via RT-PCR assay, symptoms of COVID-19 within one week prior to presenting at the hospital and an initial Chest X-ray at hospital presentation. Two independent and experienced radiologists implemented the Brixia scoring tool for the assessment of pulmonary involvement detected on CXR of patients with COVID-19.

Results: We reported cut-off values of the CXR score to be 7 for ICU admission (sensitivity=84.1%) and a cut-off score of 9 to predict the outcome of death (sensitivity=70.4%); where both values were statistically significant with p-value <0.001. Age and co-morbid conditions potentiate the CXR score.

Conclusion: Patients with a Brixia score higher than the cut-off value would require ICU admission. In addition to the Brixia scoring tool, age and pre-existing co-morbid diseases are important predictors of the clinical outcome. CXR can serve as a valuable factor for risk stratification for clinical outcome in patients with COVID-19 pneumonia

Keywords: Chest X-ray (CXR), COVID 19, *Brixia* score, Intensive care Unit (ICU)

Introduction:

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is a beta coronavirus belonging to the coronaviridae family. Originally named as 2019-novel Coronavirus (2019-nCov), it was first identified in Wuhan City, China on 12 December 2019. Meanwhile, 2019-nCov rapidly spread worldwide, posing a global health emergency. On 11 February 2020, the World Health Organization (WHO), officially named the global pandemic as COVID-19, caused by SARS-CoV-2. Coronaviruses have caused significant disease outbreaks; COVID-19 is considered to be the third outbreak following the Severe Acute Respiratory Syndrome (SARS) and the Middle East Respiratory Syndrome (MERS), that emerged in the year 2001 and 2012, respectively (1,2). A retrospective study carried out in Wuhan (Chen et al., 2020), showed that patients with COVID-19 most commonly presented with fever and shortness of breath. Signs of upper respiratory tract infection, i.e., sore throat, rhinorrhoea, headaches, anosmia, muscle aches, and diarrhoea were also commonly present in patients with COVID-19. Lung involvement by SARS-CoV-2 results in severe pneumonia, which can progress to Acute Respiratory Distress Syndrome (ARDS). The Chinese Centre of Disease Control and Prevention analysed around 72,000 COVID positive cases and reported that 80% of COVID-19 infections present as mild upper respiratory symptoms that can be managed as outpatient cases, 15% present with moderate-to-severe pneumonia requiring inpatient care while 5% of the patients present with critical symptoms leading to ARDS and septic shock thus requiring intensive care (3,4). The gold standard for the diagnosis of COVID 19 is via the detection of SARS-CoV-2 using real-time reverse -transcription-polymerase-chain-reaction assay (RT-PCR). However, RT-PCR has been subjected to false negatives, reasons for which can be attributed to the shortage of test kits, laboratory error, incorrect sampling, inadequate viral

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particles in the sample, and contamination (5). Therefore, in addition to RT-PCR, radiological evaluation of patients diagnosed with or who are suspects of COVID-19 is invaluable for the diagnosis and assessment of the extent and severity of thoracic involvement to aid in the management of COVID-19 (5,6,7). According to current literature, Computed Tomography (CT) is highly sensitive in detecting the early changes in the respiratory tree and formation of ground glass opacities in the lung parenchyma of patients with COVID-19. In addition, serial chest CT imaging shows a significant correlation with the disease progression and resolution (5,7,8). Different CT scoring systems have been utilized for the radiological quantification of thoracic involvement (1,8). However, the rise in the pandemic burden with an exponential increase in hospitalized patients has led to limited access to CT imaging facilities in medical settings. Moreover, depending on the severity of COVID-19, patients' physical condition restricts their transport to the radiology department. Hence, it is quite strenuous to perform CT imaging for monitoring COVID-19 progression (5,7). On the other hand, chest X-ray is not considered sensitive for the detection of lung abnormalities in the early stages of COVID-19. However, the use of chest X-ray (CXR), portable or bedside, has been proposed as a reliable substitute to CT imaging as it eliminates the inconvenience of transferring patients, further minimizing the risk of disease transmission. Furthermore, because of its technical ease of usage, CXR can be used to monitor disease progression by assessing the severity of lung involvement (8). The severity of pulmonary involvement in COVID-19 is an important prognostic factor for the outcome in patients with COVID-19 (6,7). Taylor et al (2015) formulated a five-point CXR scoring tool to assess the severity of pulmonary involvement in severe acute respiratory infection. Borghesi and Maroldi (2020) named this CXR scoring tool as the Brixia score and implemented it to categorize patients in 5 grades of severity based on the CXR findings of hospitalized patients diagnosed with COVID-19. In a retrospective cohort study carried out by Boari et al. (2020), they found a statistically significant correlation between a higher Brixia score with worsening clinical outcome. However, a standard CXR score is yet to be established in the medical practice. In the light of the growing pandemic, CXR grading tools are currently being utilized to test its reliability in assessing the severity and clinical outcome in patients with COVID-19 (6,7).

The purpose of this study is to implement the Brixia scoring tool to assess the pattern of lung involvement in order to predict the severity of clinical outcome in patients, where the clinical outcome correlates to outpatient, inpatient and/or ICU admission.

Patients and Methods

Research Methodology: We conducted a case series study at the Sheikh Khalifa Medical City Ajman (SKMCA), United Arab Emirates. SKMCA is a tertiary health care centre that receives a diverse range of patients. Patients' medical records were reviewed and followed up from the time of diagnosis until discharge and or death. We recruited 100 patients from 14 March to 30 October 2020 based on the following inclusion and exclusion criteria.

Inclusion criteria:

- Confirmed COVID-19 infection as diagnosed by a positive RT-PCR test
- Patients having symptoms of COVID-19 within one week prior to presenting at the hospital, and
- Patients have initial CXR on presentation at the hospital

Exclusion criteria

- Negative or inconclusive results of RT-PCR test
- Patients had symptoms more than one week before presentation at the hospital, and
- No initial CXR at presentation at the hospital.

Complete history taking, medical examination and a panel of laboratory investigations were carried out for every patient. CXR was done for patients presenting with symptoms of COVID-19 within one week prior to presenting at the hospital. Two independent and experienced radiologists used the Brixia scoring tool to assess the lung involvement detected on the CXR (the first score of each CXR examination was compared with the second score reassigned by a second experienced radiologist). A careful follow-up of the patients' medical records indicated that patients who were asymptomatic or displayed mild clinical symptoms of COVID-19, were discharged to a quarantine facility until their symptoms have resolved and PCR test turned negative.

CXR Scoring System: Brixia scoring system involves two steps of CXR image analysis. In the first step, the lungs are divided into six zones on erect CXR (anteroposterior or posteroanterior projection) by drawing two lines; Line A is drawn at the inferior wall of aortic arch and Line B is drawn at the level of the inferior wall of the right inferior pulmonary vein. These two lines divide the lungs into six zones. In the second step, a score from 0-3 is assigned to each zone depending on the lung abnormality observed on the erect CXR as follows: (Fig. 1-3)

Score 0 - no lung abnormalities

Score 1 - only interstitial infiltrates

Score 2 - both interstitial and alveolar infiltrates (interstitial predominance) and,

Score 3 - both interstitial and alveolar infiltrates (alveolar predominance)

Brixia score generates an overall CXR score from 0-18 after the summation of the individual zones.

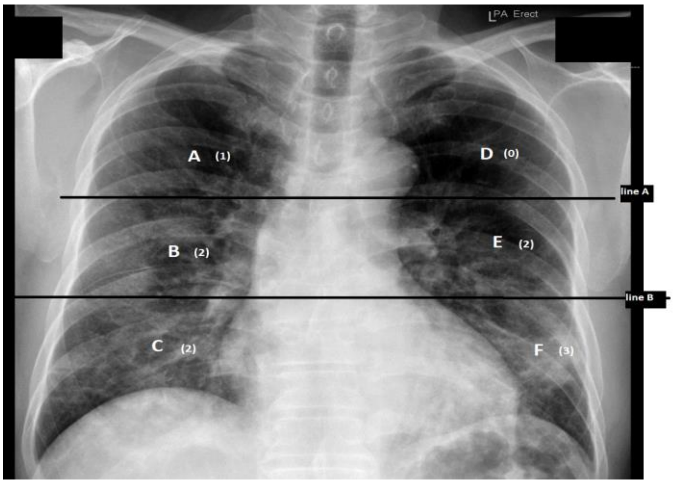


Figure 1: Brixia Scoring Tool: Division of Lung Zones into Six Divisions

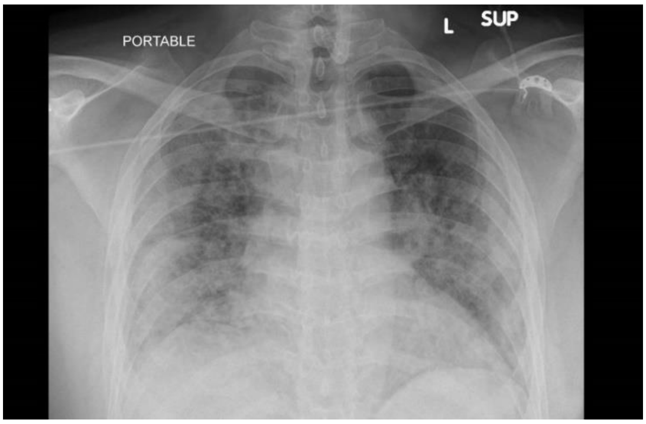


Figure 2: Brixia Score: 16
(Right upper division=2, Right middle division= 3, Right lower division=3, Left upper division= 2, Left middle division= 3, Left lower division= 3)

Figure 3: Brixia Score: 11

(Right upper division=1, Right middle division= 2, Right lower division=3, Left upper division=0, Left middle division= 2, Left lower division= 3)

Statistical Analyses:
The collected data were analysed using SPSS version 25**.** Data was analysed using means and standard deviation for quantitative variables and using frequencies and percentages for qualitative variables. We reported parametric numerical data as standard deviation, mean and range and non-parametric numerical data as median and interquartile range. Non-numerical data was reported as frequency and percentage. We used the ROC curve to evaluate the sensitivity and specificity of the CXR score to the outcome. P-value of <0.05 was considered as statistically significant.

Results
A total of 100 patients were included in the study. Of these, 83 were males and 17 were females with a mean age of 50.6 years (range: 24-84 years). Patients

had pre-existing comorbid illnesses where 64 patients had Diabetes Mellitus (DM), 74 patients had Hypertension (HTN) and 8 patients had Asthma. The relationships between demographic data, history of chronic diseases, i.e., HTN, DM, and Asthma, CXR score and clinical outcomes are summarized in table 1 and table 2. Age, DM, and CXR score were considered to be statistically significant predictors for ICU admission whereas only DM and CXR scores were considered statistically significant predictors of death in patients diagnosed with COVID-19. Of the patients diagnosed with COVID-19, 39 males and 5 females required ICU admission while 23 males and 4 females faced death. Of patients with a history of DM, 35.9% (p-value= 0.03) required ICU admission while 18.7% (p-value=0.013) faced death. Analysis of CXR using the Brixia score produced a median score of 11 for patients requiring ICU admission (interquartile range 8-13) (p-value<0.001) and a median score of 12 for patients' death (interquartile range 8-13) (p-value<0.001). Using the ROC curve analysis, we reported cut-off values of the CXR score to be 7 for ICU admission (sensitivity=84.1%, specificity=75%) (Table 3); and a cut-off score of 9 to predict the outcome of death (sensitivity=70.4%, specificity=72.6%) (Table 4). These cut-off values were statistically significant with p-value <0.001

Table 1: Associations of Demographic variables, history of chronic diseases and CXR score with patients' ICU admission

Variables and categories		Number of patients	ICU Admission		p-value
			No	Yes	
			N (%)	N (%)	
Gender	Male	83	44 (53.0)	39 (47.0)	0.184$^{(C)}$
	Female	17	12 (70.6)	5 (29.4%)	
Age (Years) - Mean ± SD			48.3 ± 11.67	53.5 ± 11.47	0.029$^{(T)}$
HTN	Yes	74	44 (59.5)	30 (40.5)	0.24$^{(C)}$
	No	26	12 (46.2)	14 (53.8)	
DM	Yes	64	41 (64.1)	23 (35.9)	0.03$^{(C)}$
	No	36	15 (41.7)	21 (58.3)	
Asthma	Yes	8	7 (87.5)	1 (12.5)	0.075$^{(F)}$
	No	92	49 (53.3)	43 (46.7)	
CXR score	Median (range)		5 (2 - 7.5)	11 (8 - 13)	<0.001$^{(M)}$

$^{(C)}$ Chi-Square test of significance (X^2= chi-square test value).
$^{(F)}$ Monte Carlo Fisher's Exact test of significance.
$^{(M)}$ Mann-Whitney test of significance (U= Mann-Whitney test value).
$^{(T)}$ Student t-test of significance (t= Student t-test value).

Table 2: Associations of Demographic variables, History of Chronic Diseases and CXR score with patients' dea*th*

Variables and categories	Number of patients		Death		p-value
			No	Yes	
			N (%) / Mean ± SD	N (%) /Mean ± SD	
Gender	Male	83	60 (72.3)	23 (27.7)	1.00$^{(F)}$
	Female	17	13 (76.5)	4 (23.5)	
Age (Years)			49.6 ± 11.67	53.3 ± 11.96	0.160$^{(T)}$
HTN	Yes	74	56 (75.7)	18 (24.3)	0.309$^{(C)}$
	No	26	17 (65.4)	9 (34.6)	
DM	Yes	64	52 (81.3)	12 (18.7)	0.013$^{(C)}$
	No	36	21 (58.3)	15 (41.7)	
Asthma	Yes	8	7 (87.5)	1 (12.5)	0.679$^{(F)}$
	No	92	66 (71.7)	26 (28.3)	
CXR score	Median (range)		6 (3 - 10)	12 (8 - 13)	<0.001$^{(M)}$

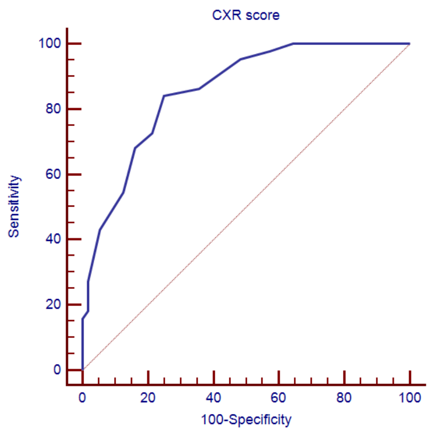
$^{(F)}$ Monte Carlo Fisher's Exact test of significance.
$^{(T)}$ Student t-test of significance (t= Student t-test value).
$^{(C)}$ Chi-Square test of significance (X^2= chi-square test value).
$^{(M)}$ Mann-Whitney test of significance (U= Mann-Whitney test value).

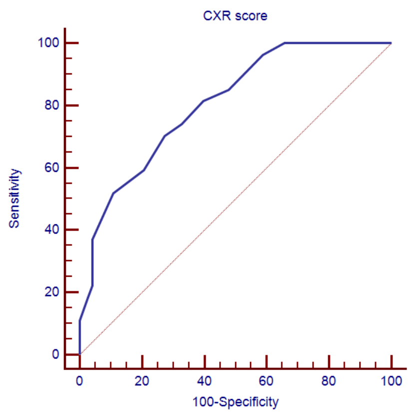
Table 3 and Figure 4: Roc curve correlating between CXR score and ICU administration

AUC	95% CI	Sig.	Cut-off value	Sensitivity	Specificity	+LR	-LR
0.857	0.773 to 0.919	<0.001	>7	84.09	75	3.36	0.21

Table 4 and Figure 5: Roc curve correlating between CXR score and death.

AUC	95% CI	Sig.	Cut-off value	Sensitivity	Specificity	+LR	-LR	+PV	-PV
0.805	0.714 to 0.878	<0.001	>9	70.37	72.6	2.57	0.41	48.7	86.9





Discussion:

The Brixia scoring system can be used for a semi-quantitative assessment to detect pulmonary involvement in patients diagnosed with COVID-19 pneumonia and to predict the clinical outcome (6,7). With the growing burden of the global pandemic, radiological assessment has become necessary for quick and efficient evaluation of COVID-19 pneumonia. Based on our study, we can conclude that the CXR grading is higher in patients with a pre-existing chronic disease. In support of recent literatures, we can infer that in addition to CXR, comorbid conditions which suppress the immune system are strong risk factors in the prediction of clinical outcome in patients diagnosed with COVID-19 (6,8). Hence, this observation can be of value to clinicians to improve risk stratification in patients diagnosed with COVID-19. Since the Brixia scoring tool depends on the quality of the CXR and observers' experience, additional research could strengthen its usefulness. However, the inter-observer agreement in our research (the first score of each CXR examination was compared with the second score reassigned by second experienced radiologist) yielded results that CXR score >7 gives high sensitivity and specificity in ICU admission and >9 gives high sensitivity and specificity in death in agreement with the results recorded in recent literatures that yielded the recovery of those who have Brixia score 4-10 and death in those having a score of 9-13 optimal cut-off value being 8 (9). Although our study sample was recruited from a single tertiary hospital, SKMCA is known to receive patients from all walks of life, nationalities and socioeconomic backgrounds. The Brixia scoring tool has been implemented in Italy only (4,6) and we believe our study could endorse its usefulness. The value of calculating the chest X ray score was higher in older age group (9), and in the presence of DM in our study in contrast to other studies (9) which did not confirm the predictive power of underlying comorbidities such as hypertension, DM and other risk factors. CT is considered as an accurate diagnostic tool in the diagnosis and grading of lung involvement in COVID-19 patients, used as first diagnostic tool in China (7). CT is highly sensitive in detecting COVID-19 findings, although this is counterbalanced by low specificity (10,11). We didn't include CT in our research to avoid exposure of staff and other patients (12), as it is time consuming and needs CT sanitization and terminal disinfection procedures following each patient which is not practical during this pandemic (7,12) In conclusion, we can implement the Brixia scoring tool to assess the pulmonary involvement on CXR. It is a clear and concise way of calculating the pulmonary involvement and can serve as an important factor to predict the severity of clinical outcome in patients diagnosed with COVID-19.

Ethical issue: As the study was based on reviewing records, no consent was obtained from patients. The research approved by the hospital education and training department and by MOHAP (Ministry of Health and Prevention) research ethics committee. No one other than researchers or ethics committee can access the data. The research will be published without sharing the data of patients involved in study.

Limitations: The scoring system slightly depends on subjective judgment of chest radiologist, still there are inter-observer variations.

Conflict of interest: none

Authors' contributions:

Dr Saabh Ibrahim: Conceived and designed the analysis, collected data, contributed data or analysis tools, and writing the paper

Dr Mustafa Albadra: Collected data, contributed data or analysis tools, and performed the analysis

Dr Fady Tadros: collected data, performed the analysis

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النتيجة الاولية للاشعة السينية للصدر في التنبؤ بنتائج مرضى فايروس كورونا في سكان الامارات العربية المتحدة

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الخلاصة:
الخلفية: قياس مدى تأثر الرئة بالأمراض عن طريق التصوير الشعاعي يعد ذا أهمية كبيرة للأطباء لتحديد طرق علاج المرضى المصابين بفيروس كوفيد 19.
الهدف: الغرض من هذة الدراسة هو تطبيق نظام **Brixia score** هو إيجاد طريقة تتضمن إعطاء نقاط عن طريق أشعة الصدر لتقدير مدى إصابة الرئة بفيروس كورونا وذلك سيساعد الأطباء توقع شدة الحالة السريرية وتوقع المضاعفات المحتملة. توقع الحالة السريرية يساعد في خطة العلاج الموضوعة التي تتضمن رقود المريض في ردهات العلاج أو العناية المركزة أو متابعة الحالة في المنزل فقط.
المرضى ومنهجية البحث: أجرينا دراسة جماعية على مجموعة من الحالات في مدينة الشيخ خليفة الطبية في عجمان – الإمارات العربية المتحدة في الفترة من 14 مارس 2020 الى 30 اكتوبر 2020. تمت مراجعة السجلات الطبية للمرضى ومتابعتها من وقت التشخيص حتى وقت الشفاء أو الوفاة. تم تضمين المرضى بناء على المعايير التالية (تأكيد الإصابة عن طرق المسحة المختبرية، أعراض المرض في غضون أسبوع قبل المجيء للمستشفى وأول أشعة صدر يجريها المريض عند قدومه إلى المستشفى. قام إثنان من أخصائيي الأشعة من ذوي الخبرة بتقييم درجة إصابة الرئة بفيروس كوفيد 19.
النتائج: الحد الفاصل لدخول وحدة العناية المركزة كان 7، أما الحد الفاصل للتنبؤ بنتيجة الوفاة كان 9. العمر والعوامل المرضية المشتركة ممكن أن تزيد من شدة الإصابة.
الخاتمة: المرضى الذين حصلوا على **Brixia score** أعلى من الحد الفاصل كانوا عرضة اكثر للرقود في وحدة العناية المركزة كما يعد العمر والعوامل المرضية المشتركة الموجودة مسبقا منبئات مهمة. تعد أشعة الصدر بمثابة عامل قيم ومهم لتصنيف المخاطر والنتائج السريرية للمرضى المصابين بالإلتهاب الرئوي.
الكلمات المفتاحية: أشعة الصدر السينية ، مرض فايروس كورونا ، مجموع نقاط بريكسيا ، وحدة العناية المركزة