



## Role Of Radiology Imaging In Covid-19 Management And Diagnosis Recommendations

Aasif Majeed Lone<sup>1\*</sup>, Aswathi P<sup>2</sup>, Manishi Shriwas<sup>3</sup>

<sup>1\*</sup>Assistant professor Dept of Radiology Centurion University of Technology & Management Vizianagram  
535003 A.P

<sup>2</sup>Assistant professor Dept of Radiology Centurion University of Technology & Management 752050 BBSR

<sup>3</sup>Assistant professor Dept of Forensic Science Centurion University of, Technology & Management  
Vizianagram 535003 A.P

**\*Corresponding Author: Aasif Majeed Lone**

\*Assistant professor Dept of Radiology Centurion University of Technology & Management Vizianagram  
535003 A.P

### Introduction

A disease in 2019 known as COVID-19 emerged from china and spread to the whole world<sup>1</sup>. Patient diagnosis : COVID-19 infection was confirmed by RTPCR test for throat swabs, nasopharyngeal<sup>2</sup>. The scoring : lung involvement scoring was done by giving a score from 0-4 to the lung on the basis of the involvements the score was considered to be 0,1,2,3 and 4 and the score was distributed as 0= least or no involvements , 1= more than 25 involvements , 2= in between 25-50, 3= in between 50-75, 4= more than 75% involvement<sup>3</sup>. RALE classification : In march 2020 the system was introduced to radiology , which was used to identify the severity of the findings in the covid-19 patients ,. Scoring on the CXR : The method was introduced to assess the involvements and pathologies in covid-19 patients . CRX : it was considered to have least sensitivity in early stage of covid-19 to detect the abnormalities , but was found active in progressive stage covid-19 patients to find the abnormalities . Computed tomography scans played a vital role for detecting lung diseases in corona virus pandemic as compared to chest x rays<sup>5</sup>. Differential Disease finding : findings on Ct images were found similar to other findings or viral diseases which were responsible for the cause of pneumonia in patients , because of the similar origin or coronaviridae virus family<sup>6</sup>. The literature was focused on CT computed tomography findings as CT has been believed to be more sensitive than chest x-ray radiographs , CT was considered to be the primary imaging modality in the COVID-19 outbreak but the chest xrays were suggested as initial method of investigation to evaluate the acute respiratory illness in some patients , it was believed that considering CT as the first line modality would lead to a burden on radiology departments and challenges in posing , pertaining to sterilization of CT suite and infection control<sup>7</sup>. The coronaviruses identified are six , out of which four cause symptoms like common cold due the (SARS) virus and the (MERS) virus which are two strains<sup>8</sup>. The epidemiological suspects of COVID-19 infection found on the CXR of the patients, performed at emergency department of that hospital were reviewed respectively. The most effected patients were found to be of age group 60-79 years old The RALE score was found to be slightly higher in Male patients than in female patients<sup>9</sup>. The chest x-rays of the in-hospital (376) patients and had gone through RTPCR were included in the study . Then the radiologist of experience greater than 10 years, categorised the radiographs into covid-19 negative or positive on the basis of image patterns<sup>10</sup>. The severity of abnormalities on the radiographs was outputted by a trained convolutional Siamese neural network-based algorithm , used the weakly supervised pre training on large number of anterior-posterior images from CheXpert<sup>11</sup>. For clinical variables the radiographs data of a month was taken to review which were examined by the radiologists to identify the abnormalities and involvements and on the basis of that a score of severity was given<sup>12</sup>. The study identified the abnormalities and findings on the Computed

tomography scans of Covid-19 patients, The change in the (GGO) into consolidation and subsequent resolution of the airspace changes were demonstrated<sup>13</sup>. The serial and baseline chest radiographs with RT-PCR were reviewed and if available the correlation with concurrent CT examination was performed<sup>14</sup>. The patient presented to the Emergency department of that hospital with confirmation of COVID-19 on RT-PCR were identified by the abnormalities and lung involvements found in the quadrants on the CXR which were studied by the radiologists<sup>15</sup>.

## CHAPTER 2

### Review of Literature

1. A prospective observational study was performed on the chest x-ray appearances of patients with positive RT-PCR test for SARS-COV2 at Pak Emirates Military Hospital Rawalpindi from April 2020 to May 2020 ,In which 1000 chest x-rays of COVID-19 patients with positive RT-PCR test were analyzed and were assessed for consolidation and location of involvement, Modified RALE scoring was used to calculate the severity index for each and both lungs. Only patients with positive RT-PCR test were included in the study, The infection was measured after creating a severity score by modifying the radiographic assessment of lung Oedema RALE score. The study was approved by the Ethical review based committee AFIRI(IERB approval certificate no:009).The study includes 932 males and 68 females with a mean age of 40.77years , majority of the cases 570 belonged to age group 21-40.Severity scores calculated and CXR reporting done by the consultants for further analyses were randomly chosen.759 patients had normal CXR's ,showed the abnormalities on reporting which highlighted the suspicion of COVID-19.
2. An observational monocentric prospective study was done to correlate the involvement of lung in chest x-ray of admission time with patients outcome and to identify the finding in chest x-ray which are associated with COVID-19 infection was performed in (April 2020)during COVID-19 pandemic descending phase in Italy ,In which 327 chest x-rays of patients o admission time were evaluated in there institute .Every chest x-ray were searched ground glass opacification ,Pneumothorax and pleural effusion. The chest x-ray showed 60% of sensitivity and 83% of specificity, which showed good correlation with COVID-19 diagnosis. To know the diagnostic accuracy of chest x-ray and radiological findings with COVID-19 presence or absence were assessed through Cohen's K Test.. During this study 327 chest x-ray s of patients with clinical suspect of COVID-19 infection out of which 30.5% were found positive for corona virus.
3. A study for patients confirmed for Corona virus disease was conducted in Tertiary Teaching hospital in the North part of Jordan .The study was done on those patients which were admitted within 35 days to the ,after two consecutive RTPCR negative test at least 72 apart the patients were discharge, Portable X-ray units were used in the digital radiographs of chest x-ray s were acquired in anterior posterior projection, In this study a total of 80 patients were admitted to the hospital out of which 50 were females and 38 were males .
4. A retrospective study was performed on the positive patients of covid-19 with initial ED ,CXR within one month in 2020. In which the patients found Positive for RTPCR, were involved. The most commonly observed alterations were GGO, lung consolidations & opacities. The CXR showed patchy,diffuse reticular opacities, consolidations, bilateral, predominance, basal and peripheral. The chest x-rays had a severity of 68.1%,Only the patients with RTPCR (+ve) test results were selected for the radiological assessment . at ED wards the DR chest X-rays were taken. The first line investigation tool recommended by the (SIRM) were the Chest X-rays .
5. In the retrospective study corona positive patients confirmed from reverse transcription polymerase chain reaction test , with CXR's , were taken for consideration and study the patients included were 366 ,with majority of females .the chest Radiographs of these patients exhibited the characteristic COVID-19 appearance , about 215 exhibited the nonspecific appearance and those considered negative for a pulmonary abnormality were 124, the reverse transcription polymerase chain reaction test taken of the 376 patients ,200 patients tested positive for Covid-19 and the rest of the 176 tested negative, image1,2.
6. The study was done on the microbiological disease caused by the virus known as COVID-19 which had led the world towards disaster and both health crisis and the economic crisis, radiologic Imaging was considered to be the most important part and effective diagnosing the disease, lungs were the mostly effected organs due corona virus is chest x-rays were the first line imaging test because they are widely and economically available .Complications to pulmonary involvement were identified by chest CT scans

which is more sensible than plain chest x-rays hence it was reserved for detecting possible complications and providing alternative diagnosis Image 3,4.

7. A retrospective study was conducted in February 2020 at a University in Pakistan , the corona positive patients with positive test results of reverse transcription polymerase chain reaction and the CXR done on presentation ,were included ,The total number of patients were 150 out of which the majority were the males patients .Initial chest x-ray was positive in 80% of the patients and the commonest comorbids seen in the patients was hypertension and diabetes mellitus and a positive initial chest x-ray result was seen in 120 of patients out of the 150 , chest x-ray severity scoring system was considered as the most effective method for the diagnosis of the abnormalities found in the corona positive patients and the chest x-ray severity scoring show strong association with ICU admission and mortality.
8. In a retrospective study a publicly available CXR dataset was taken from the hospital in which a large number of CXR of the corona positive patients were reviewed, according to which the patients that are found to be covid-19 positive were imaged mostly in the A.P positioning or the projections in the ED of the hospital .
9. In a retrospective study the patients that were presented to the ED of the hospital with corona positive results confirmed with reverse transcription polymerase chain reaction were identified , all the findings on the CXR's of the corona positive patients performed in ED were concluded, The patients that were included between the training were 499 with their chest Radiographs .Out of 499 patients the majority of the patients that of about three hundred eight patients were male out of which two forty eight were having finding that were severe and two seventy one patients were admitted that time , the intubation was done to seventy two patients and out of the total at least fifty one patients died , imaging and the clinical information improved the outcome predictions .
10. In this retrospective study the corona positive patients were included for study , the patients were find corona positive with the test reverse transcription polymerase chain reaction and were included in the study after they were identified with reverse transcription polymerase chain reaction test in this study 18 patients were included out of which 13 male and eight ,eight female patients with mean age range from 10 - 74 years.
11. The study was conducted to know the actual role of the radiology diagnosis system in finding the abnormalities and pathologies in the corona positive patients going through pneumonia the disease started from china , the virus mostly effected the respiratory system resulting in causing pneumonia in the patients , in 2019 December 31 , it was announced that some patients had emerged with a disease of newly found origin , which was later confirmed to be coronavirus or Covid-19 ,it was believed that CXR were not sensitive in early stages of the corona virus disease but were active and effective in the progressed stages of disease for finding and locating the abnormalities and the pathologies in the corona positive patients .
12. The Retrospective study was done for further understanding of the radiographic features of covid-19 the studies and the aim of the study was to define the findings and abnormalities on the CXR of corona positive patients and then relate those findings and abnormalities with the reverse transcription polymerase chain reaction. The patients included were 64 from four territory and regional hospital in Hong Kong from January 1st 2020 ro March 5 2020 ,Infection was confirmed by RT PCR test all patients underwent chest radiography at admission out of 64 patients werw 26 men and 38 women with mean age 56 years. Fever and cough by the most frequent symptoms the most common Comorbidities were hypertension and diabetes image 7,8.
13. This retrospective study was conducted on patients who were found positive for corona virus and were presented to emergency department of the hospital for the diagnosis and the corona virus positive confirmation was done with the reverse transcription polymerase chain reaction test ,the number of patients that were included in the study were 338 out of which majority of patients were male which were two hundred ten in number .
14. The study was retrospective based , in this study the patients that were included for the study had been confirmed for Corono virus with the reverse transcription polymerase chain reaction test and the patients included that were negative for thr corona virus with pneumonia should have gone through CXR , the patients who had pneumonia which was related to corona virus were included and the patients who had pneumonia which was different from the pneumonia found in the corona virus positive patients were also included and a data set was used for differentiating between the corona and the non corona pneumonia , the differentiation was done by the radiologists using data set .
15. In this retrospective study those patients were included who were presented to the ED , with respiratory syndrome or some respiratory disorders and the corona virus results were confirmed with reverse

transcription polymerase chain reaction test and the firstly taken CXR was also considered , the studies observed and compared by AI , in this study we have found that CXR , severity and the assessment was done with AI system.

16. This was a Retrospective based study , which was done on chest radiography , including the computed tomography scans and the CXR's for knowing the abnormalities and pathologies in patients who were found positive for corona virus , in this study we have found that computed tomography scans are considered to be more sensitive than CXR's in detecting the abnormalities and findings in lungs or to locate the actual lung involvements .
17. The study was done to know about the newly found scoring system which were used to evaluate the actual lung involvements and to find the abnormalities and pathologies in the lungs and to calculate the actual involvements or the densities , the CXR was suggested to be least sensitive in detecting the corona virus disease findings and abnormalities in corona positive patients in early stages but proved to be a usefull and effective in the diagnosis or progress in disease in corona virus positive patients in rapid diagnosis.
18. This study was conducted to locate and describe the abnormalities from the studies of chest or respiratory system related disease outbreak , the corona virus origin and site was explained in this study according to this study the abnormalities , findings and pathologies found in the corona virus positive patients share some similarities with the findings involvements found in the virus (SARS) and the virus (MERS).

### **CHAPTER 3**

#### **AIM & Objective**

##### **AIM**

To evaluate RALE score in patients with chest, lung abnormalities.

##### **Objectives**

1. Evaluate the RALE scoring on Radiographs of patients with lung abnormalities .
2. Compare the RALE score in different studies.

### **CHAPTER 4**

#### **Material & Methods**

##### **Study Type**

A retrospective study was carried forward in COVID-19 pandemic to evaluate chest x-ray in covid-19 patients and also compare the RALE score.

##### **Study Design**

It is a retrospective and review based study of chest x-ray in covid-19 pandemic, RALE scoring.

##### **Study Area**

SGT hospital

##### **Study Duration**

The study duration was 6 months

##### **Selection Criteria**

**Inclusion Criteria** – 1. The studies were included on the basis of the pathologies and the evaluation of the RALE score .

**Sample Size:** 30.

##### **Project and Study Design**

A prospective, observational and analysis based study on radiographers skill and knowledge. In this study the work was done to evaluate role and responsibilities of radiographer on radiation protection.

### Setting and Resources

The self-reported questionnaire was made and hard copies were distributed among radiographers of SGT hospital.

### METHADODOLOGY

This is the retrospective comparative study in which we included thirty articles in medicine using PUBS, BMJ, AJR and Google scholar, out of thirty studies 23 were prospective and 7 studies were Retrospective, In these studies we have found that RTPCR test results considered as reference and RALE scoring is evaluated on CXR's of patients who were positive for corona virus and have lung abnormalities and pathologies, The imaging technique has a big role in diagnosis of the corona virus disease, CT was suggested as effective method for detecting early lung abnormality, while as the CXR is found to be least sensitive in the diagnosis or detection of pulmonary abnormalities and other pneumonias caused by the virus, scoring system was used to determine the intensity of the disease.

**Method:** RTPCR was suggested as an important diagnostic tool for detecting the corona virus disease, RTPCR test results were considered to be medium for correlation with x-ray findings of chest, that were taken of the patients from the initial time to discharge time of the patient who were having the respiratory syndrome a scoring was done on the basis of the lung involvements and the abnormalities and pathologies found.

### CHAPTER 5

#### Result

In December 2019 the corona virus outbreak started from the Wuhan city in Hubei, China, it was later confirmed to be a virus which was originally called 2019 Novel coronavirus and on Feb, 2020 it was named as COVID19 by WHO, it was considered that corona virus has a different origin and it was also believed that the virus was found in the sea food and the virus is contagious, spreads fastly from person to person.

#### *Imaging features*

According to many studies the latest diagnostic criteria or the virus identification, via detection of nucleic acid through RT-PCR and throat swabs were considered as desired technique for locating the lung involvements of the corona positive patients, False negative results after virus detection were there which were there because of some issues with the settings, which include the least availability of the kits, which were used as initial tool for the corona virus disease diagnosis, happened also because of the technical problems in sampling and because of any issues with the laboratory and due to the non-proper technique used for the testing of the nucleic acid out of the clinical material.

#### *Radiography of chest*

In many studies we have found that chest radiography was not practiced on routinely basis as it was found that chest radiography is not sensitive for COVID19 detection in the initial stages, the CXR was considered to be sensitive only after the disease had progressed from early stage.

The pathologies that were observed on the chest radiographs after progressive stage were opacities and consolidations, in some of the studies we have observed that no obvious abnormalities were found on the chest radiographs after showing positive symptoms. In early stages of the disease chest radiographs were least sensitive for detecting any abnormalities like increased area left basilar opacity which was possibly seen atleast after 9<sup>th</sup> or 10<sup>th</sup> day of the disease progress.

#### *Computed tomography of chest*

In several studies we have found that COVID-19 typically presents with Ground glass opacities (GGO) and consolidations in a peripheral, posterior lower lung distribution or diffuse, The ground glass opacities and densities which were observed on CT scan of chest had an correlate which was extremely difficult to detect on a chest radiograph (CXR). The CT scans were performed in supine position, The scans included the upper and the inferior portions of lungs or the thoracic portion and then the taken images were reconstructed

with (1.5 - 1mm ST) as found in most of the studies. CT computed tomography scan is suggested of its early detection of the lung involvements at early stages in COVID-19 positive patients .

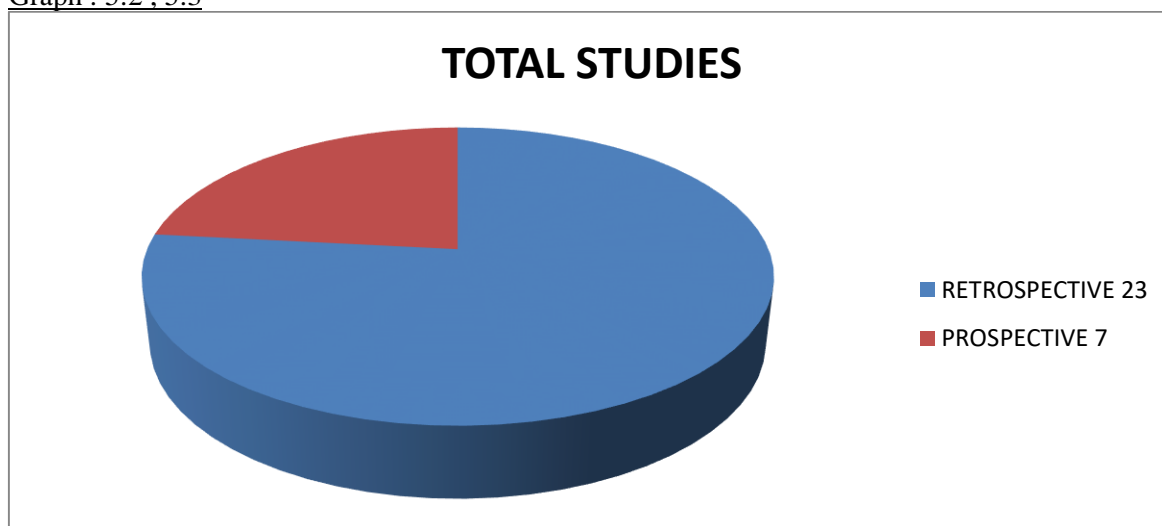
In one of the study, according to an association of the radiology branch the computed tomography scans of the corona positive patients were divided , into the different stages which include ,the Early stage ,the advance stage , the severe stage , on the basis of involvement of lungs or pathologies found Image 5,6.

In early stage the computed tomography has shown single of many patchy scattered , GGO) , The ground glass lesions were also found in peripheral and sub peripheral areas of lung . The crazy paving pattern was given due to the septal thickening which was supposed to be present in (GGO)

In Advance stage , new lesions similar to the earlier lesions were found in dense and extent state .

Severe stage , in disease progressive state ,varying density lung consolidation is seen , the patchy ground glass opacity were considered as Non-Consolidated areas of the lungs , with thickened plura . The “white out lung” appearance was considered as the major lung involvement This Retrospective study was conducted to evaluate the severity on CXR at the time Corona Virus and to compare the RALE score with RT-PCR . In this study we Reviewed at least Thirty articles on the basis of data provided in the articles in medicine using RSNA, AJR , BMJ , PUBS and PubMed out of thirty studies twenty three were retrospective and seven studies were prospective, In this retrospective study we have found that the only patients were included who were adult and were presented to the emergency department with corona virus disease.

Graph : 5:2 , 5:3

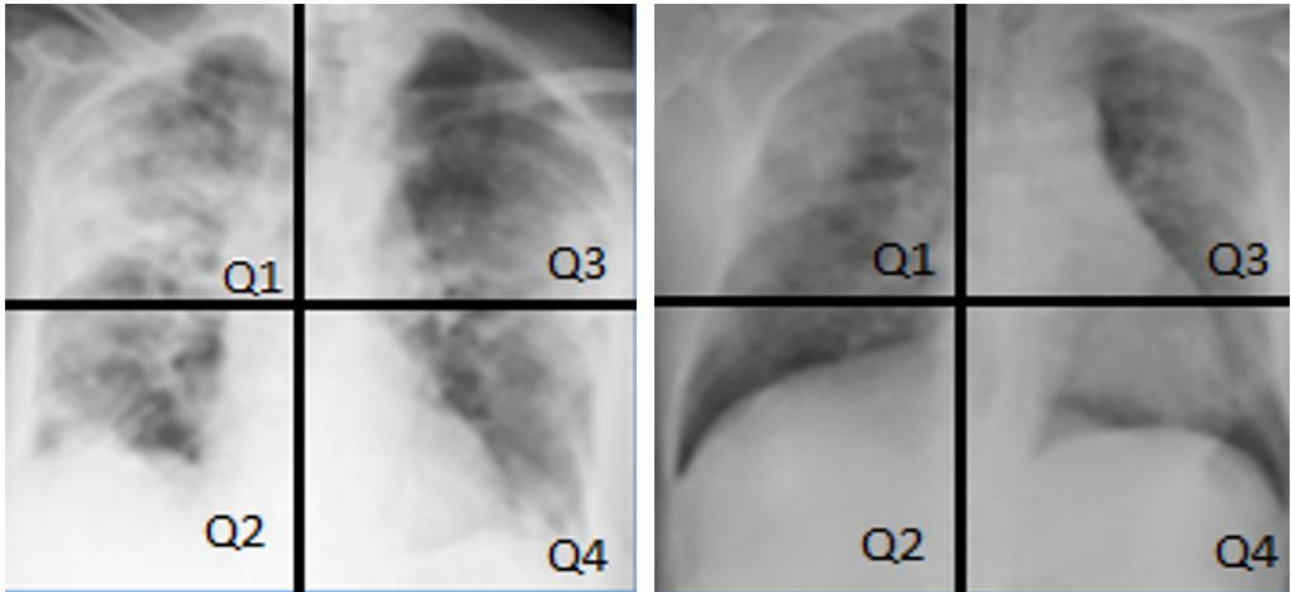


### Radiographic Findings on Chest Radiographs

- Radiographic Characteristic
- ✚ Normal chest Radiographs
  - Upper Zone predominant
  - Middle Zone predominant
  - Lower Zone predominant
  - Peripheral predominant
  - Perihilar predominant

### Quadrants for RALE scoring of Radiographs

**Image 1,2**



- Consolidation is scored for each Quadrant
- If quadrant consolidation score is – than quadrant score is 0
- Calculation of the RALE score is done for each Radiograph

**CT images findings and pathologies in patients with COVID-19 pneumonia**

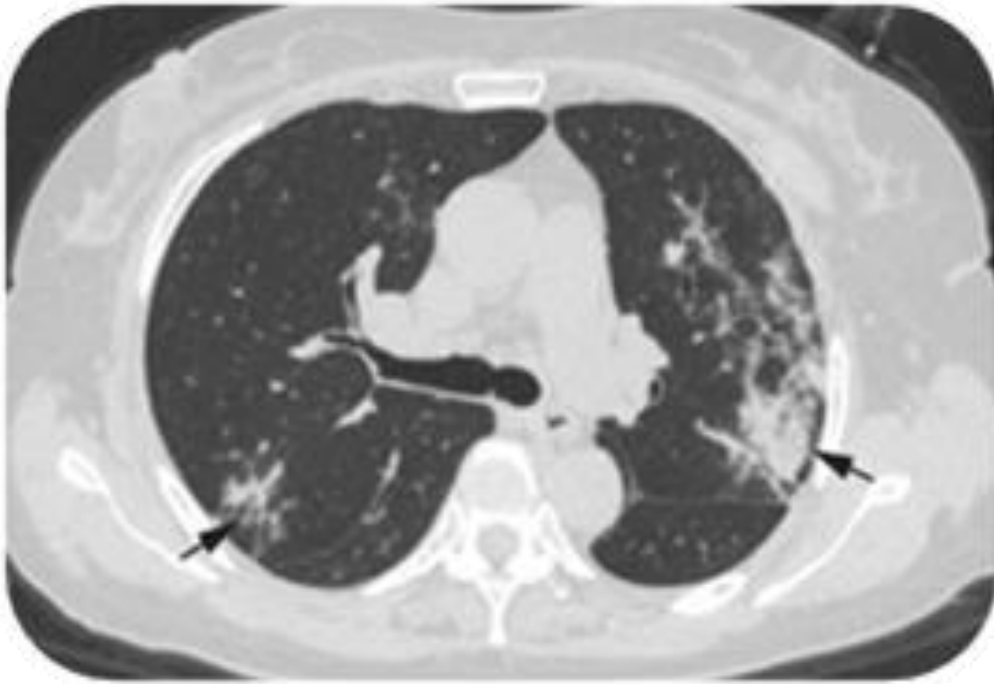
The lymph node is enlarge in this computed tomography image

**Image 3**



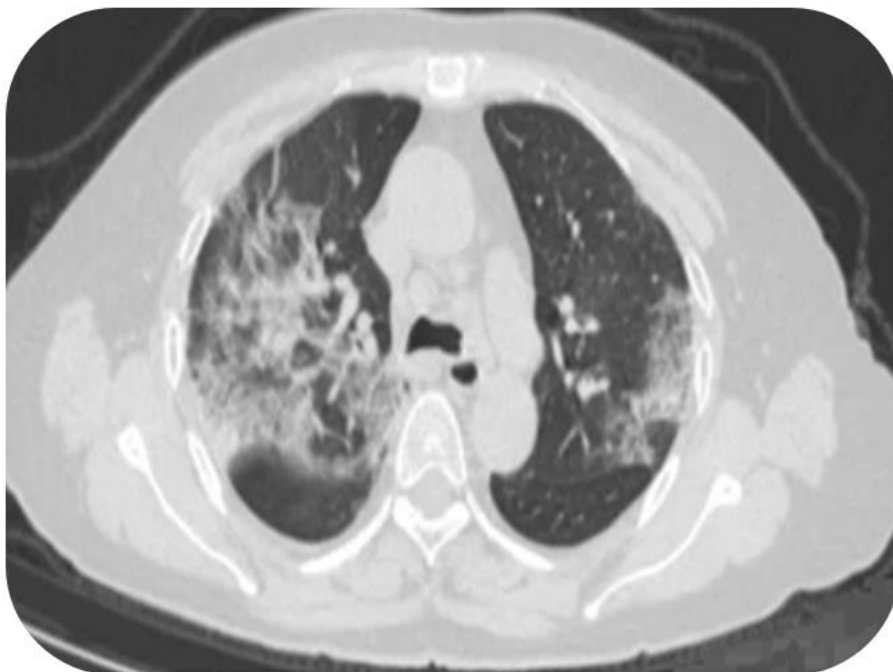
Lung computed tomography view , showing multi-focal crazy-paving pattern and consolidation.

**Image 4**



Computd tomography showing the parenchyma of Lung

**Image 5**





The enlarged lymph node shown in computed tomographic scan

**Image 6**



**Comparison of different chest X-ray of normal & COVID-19 patient's lungs.**

•Normal chest Radiographs

**Image 7**



•COVID-19 effected Radiographs

**Image 8**



## CHAPTER 6

### Discussion

According to many studies we have found that a disease was emerged among the people in china and other parts of the world , which lead the patients suffer from a kind of pneumonia with several other respiratory abnormalities which lead the patients having breathlessness and coughing , the virus responsible for this pneumonia and other chest related abnormalities was considered to be corona virus which was of the different origin and later subsequently named as the (COVID19 virus ) by the WHO and the lower portions of the respiratory system were found to be involved the most and it was considered a tough task to find differences between the CXR taken , to differentiate in symptomatic and non symptomatic corona virus patients , the study defines that an algorithm from (AI) can be used on CXR for finding the differences between the corona and the non corona abnormalities in lungs or simply the pneumonia in lungs , this data set testing and differentiating system showed good results in the (AUC). In this study we found that the outcome of the patients who were found corona virus positive , was done by artificial intelligence data set system .

The excellent results out of the artificial intelligence data set system and the score which was given by the radiologists to get known to the outcome of the diagnosis , played a vital role for the resource , constrained data set setting , at the time when corona was at its peak , the artificial intelligence also helped by getting the severity score and the clinical data of the corona positive patients for the identification of the patients who were considered to be at a risk of progression in severity and with this we can use the limited equipments and the sources accordingly .

The identification of key image findings in corona virus disease and the improvement of the effective patient management and the treatment , the findings in CXR was considered important , the patients who were severe , their findings on chest computed tomography were the bilateral , multilobar , involvements , sub segmental consolidation opacities, and the most commonly found indication was find to be ARDS , which gave the actual reason for shifting the patient to (ICU) and the same was find to be the mortality among patients in (ICU)<sup>20</sup>, It was found that RALE scoring can predict the death of the patients having corona virus and AI Scores derived from Chest x-rays , although most of the literature had focused on the use of Computed Tomographic studies in corona patients patients for assessing the complications, outcome severity of ,but according to the study the use of Chest x-ray was considered of low radiations as the radiations in computed tomography were higher , the CXR was considered easy to handle and easily to be sterilized , severity score out of AI played a vital Role in corona virus patients with pneumonia as subjective RALE Score <sup>21</sup>

In this study we have reasoned the detection of a form of pneumonia of unknown origin and the causative agent was considered to be a Novel Virus of the family coronaviridae and the disease associated with this virus was termed as COVID-19 , for this an algorithm system was used on chest radiographs, The AI system proved to be a game changer in predicting adverse outcomes , for resource- constrained settings especially for the countries with a shortage of radiological expertise and also helped in identifying the patients at higher risk of an adverse outcome so the limited resources can be allocated accordingly . The desired standard for the diagnostic criteria of the virus were RT-PCR and throat swabs via Nucleic acid detection , The chest radiographs were considered to be least sensitive for detecting COVID-19 in early stages , The correlate of Ground Glass Opacities and Densities was very difficult to be detected on a chest x-ray so Computed Tomography scan was recommended as it was found to be sensitive for early stage lung involvement detection in COVID-19 patients .

## CHAPTER 7

### Conclusion

CXR was suggested s the initial tool for the diagnosis of the severity of the corona virus , which was possible only due to the scoring systems including the RALE scoring system and the CXR scoring system , Although CXR scoring may be less sensitive than CT Scan , It is acknowledged that for patients with unexpected finding that could be attributed to COVID-19, The radiologists should follow the best practice , Parameters for communication of diagnostic imaging findings , The staff for examining should be notified to initiate (SOP's) for potential exposure .

## References –

1. Chamorro EM, Tascón AD, Sanz LI, Vélez SO, Nacenta SB. Radiologic diagnosis of patients with COVID-19. *Radiología* (English Edition). 2021 Jan 1;63(1):56-73. [https://scholar.google.com/scholar?cites=11303051106331023197&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=11303051106331023197&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
2. Moroni C, Cozzi D, Albanesi M, Cavigli E, Bindi A, Luvarà S, Busoni S, Mazzoni LN, Grifoni S, Nazerian P, Miele V. Chest X-ray in the emergency department during COVID-19 pandemic descending phase in Italy: Correlation with patients' outcome. *La radiologia medica*. 2021 May;126(5):6618 <https://doi.org/10.1007/s11547-020-01327-3> [https://scholar.google.com/scholar?cites=8119564795094566940&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=8119564795094566940&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
3. Kaleemi R, Hilal K, Arshad A, Martins RS, Nankani A, Tu H, Basharat S, Ansar Z. The 0patients with COVID-19 presenting to the emergency department of a tertiary care hospital in Pakistan. *PLoS One*. 2021 Jan 5;16(1):e0244886. <https://doi.org/10.1371/journal.pone.0244886> [https://scholar.google.com/scholar?cites=2485372348720312908&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=2485372348720312908&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
4. Cleverley J, Piper J, Jones MM. The role of chest radiography in confirming covid-19 pneumonia. *bmj*. 2020 Jul 16;370. <http://dx.doi.org/10.1136/bmj.m2426> [https://scholar.google.com/scholar?cites=14475537418461932549&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=14475537418461932549&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
5. Yang W, Sirajuddin A, Zhang X, Liu G, Teng Z, Zhao S, Lu M. The role of imaging in 2019 novel coronavirus pneumonia (COVID-19). *European radiology*. 2020 Apr 15:1-9. <https://doi.org/10.1007/s00330-020-06827-4> [https://scholar.google.com/scholar?cites=6598210955425181470&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=6598210955425181470&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
6. Palwa AR, Zafar SI, Nisar U, Halim A, Riaz S, Nayyar B. SPECTRUM OF CHEST X-RAY FINDINGS IN COVID-19 POSITIVE PATIENTS UTILIZING MODIFIED RALE SCORE FOR SEVERITY ASSESSMENT. *PAFMJ*. 2020 Sep 3;70(2):S494-500. [https://scholar.google.com/scholar?cites=10552551605524533572&as\\_sdt=2005&scioldt=0,5&hl=en](https://scholar.google.com/scholar?cites=10552551605524533572&as_sdt=2005&scioldt=0,5&hl=en)
7. [https://scholar.google.com/scholar?cites=8119564795094566940&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=8119564795094566940&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
8. Rousan LA, Eloheid E, Karrar M, Khader Y. Chest x-ray findings and temporal lung changes in patients with COVID-19 pneumonia. *BMC Pulmonary Medicine*. 2020 Dec;20(1):1-9. <https://doi.org/10.1186/s12890-020-01286-5> [https://scholar.google.com/scholar?cites=3371329690622780366&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=3371329690622780366&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
9. Cozzi D, Albanesi M, Cavigli E, Moroni C, Bindi A, Luvarà S, Lucarini S, Busoni S, Mazzoni LN, Miele V. Chest X-ray in new Coronavirus Disease 2019 (COVID-19) infection: findings and correlation with clinical outcome. *La radiologia medica*. 2020 Aug;125:730-7. <https://doi.org/10.1007/s11547-020-01232-9> [https://scholar.google.com/scholar?cites=14804095624286829568&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=14804095624286829568&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
10. Smith DL, Grenier JP, Batte C, Spieler B. A Characteristic Chest Radiographic Pattern in the Setting of the COVID-19 Pandemic. *Radiology: Cardiothoracic Imaging*. 2020 Sep 3;2(5):e200280. <https://doi.org/10.1148/ryct.202020028> [https://scholar.google.com/scholar?cites=8433330497141687845&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=8433330497141687845&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
11. Li MD, Arun NT, Gidwani M, Chang K, Deng F, Little BP, Mendoza DP, Lang M, Lee SI, O'Shea A, Parakh A. Automated assessment and tracking of COVID-19 pulmonary disease severity on chest radiographs using convolutional siamese neural networks. *Radiology: Artificial Intelligence*. 2020 Jul 22;2(4):e200079. <https://doi.org/10.1148/ryai.2020200079> [https://scholar.google.com/scholar?cites=5055667000560704421&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=5055667000560704421&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
12. Kwon YJ, Toussie D, Finkelstein M, Cedillo MA, Maron SZ, Manna S, Voutsinas N, Eber C, Jacobi A, Bernheim A, Gupta YS. Combining Initial Radiographs and Clinical Variables Improves Deep Learning Prognostication in Patients with COVID-19 from the Emergency Department. *Radiology: Artificial Intelligence*. 2020 Jul 22;2(4):e200079. <https://doi.org/10.1148/ryai.2020200079>

- Intelligence. 2020 Dec 16;3(2):e200098. <https://doi.org/10.1148/ryai.2020200098>  
[https://scholar.google.com/scholar?cites=3566451389687028852&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=3566451389687028852&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
- 13.13.Ng MY, Lee EY, Yang J, Yang F, Li X, Wang H, Lui MM, Lo CS, Leung B, Khong PL, Hui CK. Imaging profile of the COVID-19 infection: radiologic findings and literature review. *Radiology: Cardiothoracic Imaging*. 2020 Feb 13;2(1):e200034. <https://doi.org/10.1148/ryct.2020200034>  
[https://scholar.google.com/scholar?cites=4249711248896066062&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=4249711248896066062&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
- 14.14.Wong HY, Lam HY, Fong AH, Leung ST, Chin TW, Lo CS, Lui MM, Lee JC, Chiu KW, Chung TW, Lee EY. Frequency and distribution of chest radiographic findings in patients positive for COVID-19. *Radiology*. 2020 Aug;296(2):E72-8. <https://doi.org/10.1148/radiol.2020201160>  
[https://scholar.google.com/scholar?cites=641843427615545027&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=641843427615545027&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
- 15.15.Toussie D, Voutsinas N, Finkelstein M, Cedillo MA, Manna S, Maron SZ, Jacobi A, Chung M, Bernheim A, Eber C, Concepcion J. Clinical and chest radiography features determine patient outcomes in young and middle-aged adults with COVID-19. *Radiology*. 2020 Oct;297(1):E197-206. <https://doi.org/10.1148/radiol.2020201754>  
[https://scholar.google.com/scholar?cites=7606797573324369691&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=7606797573324369691&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
- 16.20.Salehi S, Abedi A, Balakrishnan S, Gholamrezanezhad A. Coronavirus disease 2019 (COVID-19): a systematic review of imaging findings in 919 patients. *American Journal of Roentgenology*. 2020 Jul;215(1):87-93. [doi.org/10.2214/AJR.20.23034](https://doi.org/10.2214/AJR.20.23034)  
[https://scholar.google.com/scholar?cites=678459639070219410&as\\_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19](https://scholar.google.com/scholar?cites=678459639070219410&as_sdt=2005&scioldt=0,5&hl=en&scioq=spectrum+of+chest+x+ray+findings+in+COVID-19)
- 17.21.Ebrahimian S, Homayounieh F, Rockenbach MA, Putha P, Raj T, Dayan I, Bizzo BC, Buch V, Wu D, Kim K, Li Q. Artificial intelligence matches subjective severity assessment of pneumonia for prediction of patient outcome and need for mechanical ventilation: a cohort study. *Scientific Reports*. 2021 Jan 13;11(1):1-0. <https://doi.org/10.1038/s41598-020-79470-0> <https://www.nature.com/articles/s41598-020-7947>