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Can Chest X-Ray Findings Predict the Prognosis, Clinical Outcome, and Mortality in Serologically Confirmed COVID-19 Patients?

Serena Virdi, Zereda Zulkeefli, Josiah Damisa, Imroz Sachdev, Sarath Bethapudi

Department of Radiology, University Hospital of North Durham, United Kingdom

Abstract

Background: Reverse transcription-polymerase chain reaction tests are currently used to diagnose COVID-19. However, they have sensitivity rates as low as 60%-70%. There is now growing interest in the role and appropriateness of chest radiographs and computed tomography for both the diagnosis and management of patients with suspected or known COVID-19. This study aimed to retrospectively identify the correlation between chest x-ray findings on admission and clinical outcome and mortality in COVID-19 patients.

Methods: A retrospective study was carried out across 2 district general hospitals involving a cohort of 40 patients, with confirmed COVID-19 via reverse transcription-polymerase chain reaction testing over a period of 1 month. Clinical findings, severity of symptoms, outcomes, and mortality in these patients were correlated with chest radiograph findings on admission and throughout their hospital stay.

Result: Our study revealed that patients presenting with a normal chest radiograph on admission had a more favorable outcome when compared to those with panlobar involvement, who were shown to have a worsened prognosis with an increased mortality rate.

Conclusion: In summary, our study has highlighted parallels between the baseline chest radiographic features seen in patients with confirmed COVID-19 compared to their clinical outcome.

Keywords: COVID-19, radiology, x-ray

Introduction

On March 11, 2020, the World Health Organization (WHO) declared the COVID-19 outbreak as a pandemic. At present, the number of cases continues to rise both in the UK and on a global scale.[1] Current clinical trials are being undertaken to learn more about the virulence and the symptoms individuals present with. As the cases progressed, it became well understood that the concern for affected patients was the progression to acute respiratory distress syndrome (ARDS) and potential fatality.[2] At present, diagnostic investigations are mainly focused on molecular testing with real-time reverse transcription-polymerase chain reaction (RT-PCR). Although the RT-PCR test is highly specific, it is noted to have sensitivity rates as low as 60%-70%.[3] There is now growing interest in the role and appropriateness of chest radiograph (CXR) and computed tomography (CT) for both the diagnosis and management of patients with suspected or known COVID-19.

The radiological findings of COVID-19 on CXR and CT are representative to that of pneumonia. Current publications have identified chest radiographic features of bilateral patchy ground-glass opacities, often located more peripherally.[4] Further studies have also identified other primary CT changes including broncho-vascular thickening, traction bronchiectasis, and air space consolidation.[5] However, it has also been reported that some positive COVID-19 cases have demonstrated normal CXRs, particularly at the early stages of the disease.[6,7] The British Society of Thoracic Imaging (BSTI) has expressed their current position regarding the use of CT by stating, "there is no recommended use of CT beyond routine clinical care."[8] Therefore, hospitals in the United Kingdom have employed CXRs as first-line imaging tools, particularly with the long RT-PCR turnaround times.[9] With an increasing number of radiological investigations for affected patients, a better understanding of the radiographic features of COVID-19 and whether temporal CXRs are a satisfactory predictor of clinical

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Corresponding author: Serena Virdi, e-mail: serena.virdi@nhs.net

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prognosis is warranted. These findings could not only be invaluable to the management of the disease and clinical prognosis but also to the potential long-term effects of COVID-19 on lung parenchyma.

Materials and Methods

Our study was conducted in 2 regional hospitals based in the North East of England; in patients who presented to the Accident and Emergency (A&E) Departments, over a 1-month period (March 27, 2020, until April 27, 2020), with a provisional COVID-19 diagnosis stated on their discharge summary was initially selected for the study. Out of these patients, a total of 40 patients had a positive COVID-19 test result via RT-PCR on nasopharyngeal and throat swabs and were deemed eligible for the study. Admission CXRs and any subsequent radiographic imaging during their admission were collected via the local Picture Archiving Communications System (PACS) system. Demographic data including age and gender, as well as clinical information (co-morbidities, oxygen saturation on presentation, blood results), were collected from A&E clerking notes. Discharge summaries were used to assess maximum oxygen requirement during admission and clinical outcome (discharged/died).

All CXRs were reviewed by radiology registrar under the supervision of consultant radiologist via the local PACS system. The readers assessed the presence and location of radiographic changes, which included: ground-glass opacification, focal alveolar consolidation, and diffuse alveolar consolidation. The severity of these changes was quantified according to the number of lobes involved (0-5) on the admission CXR; with 0 indicating a normal CXR and 5 indicating pan lobar involvement. Further quantification of the severity of chest radiographic changes on any serial imaging was also carried out in the same way.

The imaging patterns typical of COVID-19 infection including peripheral ground-glass opacities, infiltrates, consolidations (unilateral and bilateral), and ARDS- like appearance were graded based on their distribution. A 5-lobe involvement would typically mean ARDS-like picture. Data collaborated onto an Excel spreadsheet for analysis.

Ethics committee approval was not required for this study as data were collected retrospectively and resulted in no change to the treatment and management of individual patients.

Results

Patient Characteristics

Out of the 40 patients, there were 14 males (35%) and 26 females (65%), with a mean age of 65 (range, 22-92 years). The most common presenting symptoms included cough, fever, and shortness of breath and 36 patients (90%) had pre-existing co-morbidities with the remaining 4 (10%) having no past medical history. The most common co-morbidities were hypertension (49%) and diabetes (34%) followed by Chronic Obstructive Pulmonary Disease (COPD), asthma, and ischemic heart disease. Patients with the worst prognostic outcomes were those aged 45 years and older, with the highest percentage of deaths (23%) being in the 81-85 age group. Furthermore, 100% of patients who died had co-morbidities, with hypertension being the most prevalent (69%). This is comparably higher to the cohort of patients who were eventually discharged, as only 85% had pre-existing conditions.

The oxygen saturation at presentation ranged between 60% and 99%. The majority of patients (42.5%) presented with oxygen saturations in the range of 90%-94%. Notably, most of those patients (78%) who were successfully discharged had initial saturations greater than 90%, whereas majority of those who died (62%) presented with saturations less than 90%. During their admission, 29 patients (73%) needed oxygen supplementation via nasal canula or venturi, while 5 patients (12%) required continuous positive airway pressure (CPAP) and Intensive Therapy Unit (ITU) support. Furthermore, oxygen supplementation was required in all those patients who died with a quarter requiring non-invasive ventilation, such as CPAP.

The eventual outcome of our cohort was 13 deaths (32%) and 27 patients (66%) discharged back to the community.

Radiographic Results

On admission, all 40 patients had CXRs at the same time that their RT-PCR testing was obtained. Out of the 40 patients, a total of 27 patients (68%) had radiographic changes at the time of admission, with 13 patients (32%) presenting with normal CXRs. The average number of lobes involved on admission CXRs was 2 (range, 1-5).

All 13 patients with normal x-rays on admission made complete recovery and were discharged from the hospital. Mortality was recorded in all 4 patients with 5-lobe involvement/ARDS pattern on admission chest x-ray.

There were 14 patients who had serial CXRs during their admission, ranging from a total of 2-5 images. Out of the 27 patients presenting with radiographic changes on admission, only 6 (22%) were found to have progressive radiographic changes over the course of their hospital stay.

There was no significant correlation between radiological findings and clinical outcomes in patients with 1-4 lobes involvement on admission chest x-ray and radiological changes on interval follow-up chest x-rays.

Table 1. Correlation of Chest x-Ray Findings with Co-morbidities and Outcomes of Patients

CXR Finding	Total	Co-morbidities	CPAP Needed	Recovered	Deceased
Normal	13	12	0	13 (100%)	0 (0%)
1 lobe	6	6	0	3 (50%)	3 (50%)
2 lobes	8	6	2	6 (75%)	2 (25%)
3 lobes	3	3	0	2 (66.66%)	1 (33.33%)
4 lobes	6	5	0	3 (50%)	3 (50%)
5 lobes/ARDS pattern	4	4	3	0 (0%)	4 (100%)

CXR, chest radiograph; ARDS, acute respiratory distress syndrome.

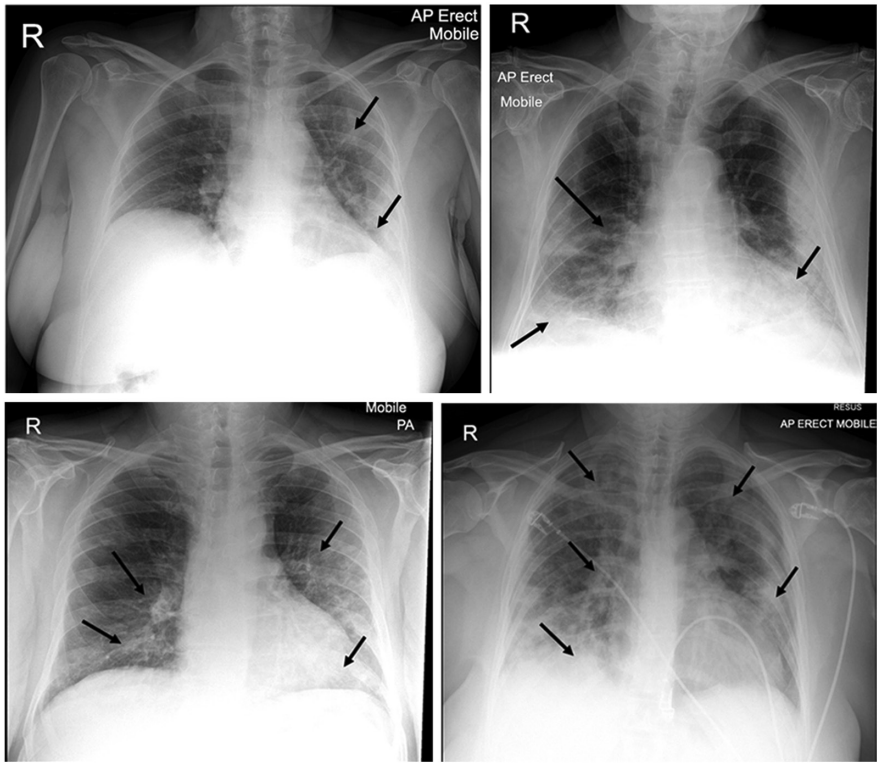

Figure 1. A-D. (A) Opacification of two left lobes. (B) Opacification of three lobes in both lungs. (C) Opacification of four lobes in both lungs. (D) Panlobar opacification (ARDS) in both lungs.

Discussion

The initial CXR was positive in 68% of PCR-positive COVID-19 patients on admission, and thus, RT-PCR testing has a higher sensitivity rate, a finding similar to that of Wong et al[6] found baseline CXRs to have a sensitivity of 69%. A further retrospective study involving a similar age cohort to ours also found baseline CXR to have a sensitivity of 67.1%.[10]

There was a correlation between admission CXRs and patient outcome, as patients showing radiographic changes at admission were more likely to die compared to those with normal CXRs. Majority of the patients who died had involvement of all 5 lobes/ARDS pattern on their admission CXR. This is in contrast to those who were discharged, who mainly presented with a normal CXR. A comparable study evaluating the prognostic value of admission CXRs in a cohort of 338 patients with COVID-19 concluded that the severity of radiographic features was predictive of risk for hospital admission and intubation.[11] Although, this study focused on a cohort of patients younger than our cohort (21-50 years), it used a similar severity score to quantify the radiographic features on admission CXR. Furthermore, the study also showed that those patients who died were also those who had higher chest severity scores on initial chest imaging.

The progression of radiographic features on serial chest imaging did not appear to strongly correlate with clinical deterioration. Our results showed that 6 out of the 10 patients who had progressive changes on serial CXRs were discharged and only 1 required intensive care support. This is an area that potentially needs to be expanded on. A case report evaluating the overall benefit of chest imaging in the management of COVID-19 patients highlights the importance of serial imaging in relation to the clinical status of the patient. For example, it suggests that in confirmed COVID-19 patients, imaging is useful in establishing baseline pulmonary status and any underlying cardiopulmonary abnormalities. It also explains that further imaging is indicated only if the patient clinically deteriorates and not in those who are clinically stable.[12] These benefits of serial imaging in admitted COVID-19 patients need to be carefully considered and cautiously implemented, given the risk of transmission to both hospital staff and uninfected patients.

Our study is limited by small sample size (n = 40). Study findings are also largely based on initial chest x-ray at admission, with limited data on recurrence and re-admissions in those who were discharged following recovery from acute phase illness. Medium to long-term sequelae of the disease process is beyond the scope of this study. Recent findings from the real-time assessment of community transmission study showed that around a third of those infected with COVID-19 had persisting symptoms lasting over 12 months "long COVID" and that those admitted to hospital were at increased risk of developing long COVID.[13] Given that initial chest x-ray findings in this study bared some prediction for clinical outcome within hospital, it would be useful to understand their relevance in predicting patients at risk of developing long COVID.

In summary, our study has highlighted parallels between the baseline chest radiographic features seen in patients with confirmed COVID-19 compared to their clinical outcomes. Despite the small sample size, our study reveals favorable clinical outcomes and recovery for patients with normal chest x-ray at admission. Panlobar involvement and ARDS pattern on

admission chest x-ray are associated with poor clinical outcomes and increased mortality. Co-morbidities and oxygen saturations at the time of presentation also have a bearing on clinical prognosis and recovery. Chest x-ray findings on admission in conjunction with co-morbidities and oxygen saturation levels can help identify patients at risk of rapid clinical deterioration and plan step-up in care, at an early stage. However, chest x-ray is not a diagnostic tool for COVID-19 infections and should not be used as an alternative to RT-PCR testing. We recommend further studies involving a larger sample size for further evidence and a better understanding of the utility of chest x-rays in predicting clinical outcomes and mortality, as well as its use for predicting patients at risk of developing persisting COVID symptoms.

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