Chest x-ray findings and temporal changes among adult patients with COVID-19 admitted to a tertiary referral center

Julian A. Santos, Johanna Patricia A. Cañal

Department of Radiology, University of the Philippines Manila – Philippine General Hospital, Taft Avenue, Ermita, Manila, 1000, Philippines

Department of Radiology, College of Medicine, University of the Philippines Manila – Philippine General Hospital, Taft Avenue, Ermita, Manila, 1000, Philippines

HIGHLIGHTS

- Ground-glass opacities are the most common chest x-ray findings.
- Pleural effusion and high disease extent scores are associated with mortality.
- Serial chest radiography is useful in monitoring COVID-19 in adult patients.

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ABSTRACT

Purpose: To describe the radiographic findings of hospitalized adult Filipino COVID-19 patients on serial chest x-ray imaging.

Method: We performed a retrospective review of records and chest x-rays of eligible adult Filipinos with confirmed COVID-19 admitted from 1 March 2020 to 31 July 2020. Demographics, clinical outcomes, and chest radiographic findings were recorded. Serial chest x-ray findings were correlated with the clinical outcome.

Results: From 144 adult patients (93 males and 51 females), a total of 785 chest x-rays were reviewed (144 baseline and 641 follow-up). The most common finding overall is ground-glass opacity. The most common distribution pattern is bilateral, patchy/diffuse involvement of the central/peripheral zones. In x-rays taken after the third admission day, reticular opacities become more common than consolidation. The radiographic extent score was higher for deceased patients compared to the survivors at Day 7–9 (6 vs 4.4, p-value = 0.0011), Day 10–12 (5.9 vs 4.1, p-value = 0.0297) and Day 13–15 (5.5 vs 4.1, p-value = 0.0297). The presence of endotracheal tubes (68 % vs 7.5 %, p-value < 0.001) and pleural effusion (70 % vs. 36 %, p-value = 0.0004) were higher among the deceased. Reticular opacities were more common for discharged patients (50 % vs 30 %, p-value = 0.0021).

Conclusion: Ground-glass opacities with bilateral, patchy/diffuse involvement of the central/peripheral zones are the most common findings. The presence of endotracheal intubation, pleural effusion, and persistently elevated radiographic extent scores are typically seen in deceased patients. Serial chest radiography with radiographic extent scoring is a useful tool in monitoring COVID-19 for hospitalized adult patients.

1. Introduction

A novel coronavirus was isolated from the respiratory tract samples of patients after an outbreak of severe pneumonia was reported in Wuhan, China in late December of 2019 [1–4]. The disease eventually spread globally. On 30 January 2020, the World Health Organization (WHO) announced that this new disease – COVID pneumonia – was a public health emergency of international concern, and on 12 March 2020, the WHO declared the disease as a full-blown global pandemic [1, 2, 5]. In the Philippines, the first confirmed case was reported on 30 January 2020, and local transmission of COVID-19 was reported on 7 March 2020 [6].

The CXR findings are very non-specific and can be normal in early stages of the disease. In a study by Wong, et al. [7], CXR has a sensitivity of 69 %, where the most common finding was bilateral lower lung zone consolidation that peaked at 10–12 days from onset. Another typical
radiographic finding is multifocal ground-glass opacities with peripheral predominance [2,8]. Bronchiectasis, pleural effusion, and pulmonary cavities are much less common [8,9]. The diagnosis of COVID-19 infection is established by detecting viral RNA from respiratory specimens through nucleic acid amplification tests such as real-time reverse-transcription polymerase chain reaction (RT-PCR) [10]. Early in the pandemic, when RT-PCR tests were difficult to come by, there was initial interest in diagnosing COVID via imaging (chest x-ray and chest CT scan). The American College of Radiology (ACR) and the US Centers for Disease Control (CDC) released a statement regarding the utility of diagnostic imaging as early as March 2020, followed soon after by concurring statements by the Philippine College of Radiology (PCR) and the CT-MRI Society of the Philippines (CTMRISP). All stated that, given the available data, they do not recommend the use of CXR or CT to diagnose COVID-19. Instead, confirmation of diagnosis should still be made through laboratory tests [11,12]. The Philippine Society for Microbiology and Infectious Diseases (PMSID) and other medical societies drafted local clinical guidelines for the management of COVID-19. They recommended that chest imaging, i.e., chest x-ray and CT, is reserved for moderate, severe, and critical cases of COVID-19. They suggested that the clinicians may periodically repeat chest radiographs every 3 days, or when the patient clinically deteriorates. As for chest CT, no definite periodic follow-up is recommended [3]. Until this study, there is a paucity of reported data regarding imaging findings of COVID-19 in the Philippines. Since majority of the data is obtained from international studies, it is important to perform local validation studies to note their applicability to Filipino patients and determine possible nuances in the imaging findings. Describing changes in the pattern, distribution, and extent of chest radiographic findings would aid in guiding management and clinical decision-making, particularly in resource-limited settings. This study describes the prevalent chest radiographic findings of hospitalized adult Filipino patients with COVID-19 and to investigate the imaging features, distribution, and temporal changes on serial x-ray imaging.

2. Methods

2.1. Study design

A retrospective, cross-sectional study design was utilized using available patients’ medical and imaging records. There was no direct patient participation, contact, or interaction. The study was approved by the University Research Ethics Board. Waiver of informed consent was granted.

The records of patients admitted for COVID-19 at from 1 March 2020 to 31 July 2020 were reviewed. Patients who were less than 18 years of age were immediately excluded. Also excluded were suspect or probable COVID cases with no RT-PCR confirmation and patients without a completed clinical outcome (discharged vs. deceased). To be included in this study, these COVID patients must have had laboratory confirmation of COVID-19, at least 4 chest x-rays (posteroanterior or anteroposterior views) during the course of their admission and a medical record that definitively states the final clinical outcome. The initial x-ray is the admission chest x-ray. The next 3 or more x-rays should have been over the course of at least the next 7 days. The 2nd x-ray should have been from Day 1–3 of admission. The 3rd and 4th x-rays should be from subsequent 3-day periods. The 3-day subgroups were adopted from the local clinical recommendation to do a chest x-ray every 3 or more days. In cases wherein there are multiple x-rays taken in a subgroup, the x-ray with the most extensive involvement was chosen for that particular subgroup. The chest radiographs of the patients were followed up until their discharge.

A list of laboratory-confirmed COVID-19 patients with at least 4 eligible x-rays was consolidated and each patient was cross-referenced against their electronic medical records. Demographic data (name, age, and sex) and admission details (location, date of admission, final clinical outcome, and date of clinical outcome) were obtained and were kept in a confidential database. The authors subsequently evaluated all the eligible x-rays and entered this information into an encrypted digital database.

2.2. Image interpretation

Lung lesions were described and characterized by consensus of the authors into ground glass, nodular, reticular, reticulonodular, and consolidated [13]. Relevant findings of the heart, pleura, and airways, and the presence of endotracheal tubes were recorded as well. The investigators were blinded to the clinical outcome while evaluating the chest x-rays. Furthermore, for each chest radiograph, a disease extent score was assigned per lung, adapted from Radiographic Assessment of Lung Edema Score proposed by Warren, et al. (Table A1). Each lung received a score of 0–4, depending on the extent of involvement of each lung lobe by the lung lesions. A score of zero (0) indicates that the lung is uninvolved or normal. A score of one (1) indicates less than 25% involvement. Scores of 2 and 3 represent 25–50% and 50–75% respectively. A score of 4 is the maximum per lung and describes an involvement of >75% of each lung. The scores of the right and left lungs were added—hence, the lowest possible score of a patient is 0 while the highest is 8 [7].

2.3. Statistical analysis

Means, medians, and standard deviations were computed for continuous/quantitative variables. Frequencies and percentages were obtained for categorical/qualitative variables. The distribution of the total CXR radiographic scores will be presented per time point, and the prevalence per time point were plotted. Day 0 will be defined as the day of admission in the wards or ICU. Prevalence is presented as a percentage, together with a 95% confidence interval. Average CXR radiographic scores of survivors and expired patients were compared using the Mann Whitney U test; while the chi-square test for independence or Fisher’s exact test were used to compare the frequency of CXR radiographic findings between patients who expired versus patients who survived. Statistical significance was defined as p < 0.05.

3. Results

3.1. Patient demographics

There were 144 eligible patients who had 4 or more x-rays during their confinement. This set of patients was composed of 93 males and 51 females. The average age was 59 years, with a range of ages of 23–86 years. These patients represent a total of 785 chest x-rays that were reviewed: 144 chest x-rays at baseline and 641 chest x-rays as follow-up.

The over-all shortest hospital admission was 7 days and the longest was 82 days. Of the 144 patients included in this study, 107 patients (74%) were eventually discharged while 37 patients (26%) eventually died. Beginning at the collection range of 16–18 days, majority of the patients have either died or have been discharged, with only 27 of the initial 144 patients (19%) still admitted. This precluded appropriate statistical evaluation of this data range and the subsequent date ranges.

3.2. Baseline chest x-ray findings

On admission, only five patients (3.5%)—3 males and 2 females—had completely normal x-rays. They were admitted because of symptomatology, age, and a positive RT-PCR swab. Their ages ranged from 37 to 67 years with the three other patients in their 50s. Three of the 5 patients had normal chest x-rays for the whole duration of their admission chest x-ray. The next 3 or more x-rays should have been over the course of at least the next 7 days. The 2nd x-ray should have been from Day 1–3 of admission. The 3rd and 4th x-rays should be from subsequent 3-day periods. The 3-day subgroups were adopted from the local clinical recommendation to do a chest x-ray every 3 or more days. In cases wherein there are multiple x-rays taken in a subgroup, the x-ray with the most extensive involvement was chosen for that particular subgroup. The chest radiographs of the patients were followed up until their discharge.
hospital admission. For the 2 patients whose chest x-rays showed disease progression, their worst extent scores were 6 and 8. All were discharged by the 10th hospital day.

Three other patients (2.1 %) had no lung parenchymal lesions suggestive of pneumonia at the time of admission but had cardiomegaly or pleural effusion.

The remaining 136 patients (94.4 %) had abnormal lung parenchymal lesions/pulmonary opacities at baseline. The most common lung parenchymal finding at baseline was ground-glass opacities (GGO), seen in 120 patients (83.3 %), followed by consolidation, seen in 30 patients (20.8 %). The three most common non-parenchymal abnormal chest findings are cardiomegaly (59/144; 41 %), pleural effusion (43/144; 30 %), and endotracheal tube placement (16/144; 11 %). Only 1 of the 144 patients ever manifested with pneumothorax – an elderly female patient whose extent score was persistently above 6 and eventually succumbed to the disease.

The predominant distribution of pulmonary opacities at baseline was “both central and peripheral” (diffuse), seen in 77.8 % of patients. Twelve patients had central pneumonia and another 12 patients had peripheral pneumonia at baseline. Across all lung parenchymal lesions described, the predominant zonal location is bilateral and patchy/diffuse (Fig. A1).

Among patients with pleural space findings at baseline, pleural effusion is most common, the location was more or less evenly distributed between unilaterally left, unilaterally right, and bilateral (Fig. A2).

The mean baseline radiographic extent score was 5.4 ± 2.66. Furthermore, the average baseline radiographic extent was not significantly different between those who died (5.7) and those who were discharged (5.2) (Table A2).

3.3. Distinctive findings amongst discharged patients

One hundred seven (107) out of the 144 patients were discharged after their bout with COVID. Thirty-four (34) were female and 73 were male. The youngest patient was 23; the oldest was 82. The average hospital stay was 28 days with a range of 8–81 days. Only 6 of the 107
discharged patients (5.6 %) were ever admitted at the ICU.

The most common lung parenchymal finding for discharged patients are ground glass opacities, found in 96 of the 107 (89.7 %) of these patients. The second and third most common findings for discharged patients were reticular opacities (64 out of 107, 59.8 %) and consolidation (35 out of 107, 32.7 %), respectively (Table A3).

Their CXR extent scores ranged from 0 to 8. Eight patients had and extent score of zero at baseline. Sixty-nine (69) patients had worst radiographic extent scores that can be considered severe disease (6, 7 or 8). Forty-one patients out of the 107 discharged patients (38 %) ever had a worst extent score of 8, ten patients (9%) had a worst extent score of 7, and eighteen patients scored 6. These scores imply diffuse bilateral disease. On the other hand, 18 patients had 0, 1 or 2 as their worst extent score, i.e., radiographically mild disease.

Only 7 out of the 107 discharged patients (6.5 %) exhibit worsening radiographic extent scores throughout their course of admission, i.e., their scores exhibit persistent/gradual increase in the serial follow-up x-rays. Majority of the patients showed improvement (79 patients, 73.8 %). Whereas the remaining 21 patients (19.6 %) showed radiographically stable disease.

From the 107 discharged patients, there were 36 who had last extent scores of 5 or over even upon discharge. It is interesting to note that from these 36 patients with radiographically-significant disease even upon discharge, 16 (44.4 %) had reticular opacities in their pre-discharge x-ray while 7 (19.4 %) had ground glass opacities. The remaining 13 (36.1 %) had pre-discharge x-ray findings of either reticulonodular, nodular, or consolidated opacities.

### 3.4. Distinctive findings amongst deceased patients

Of the 37 patients who died of COVID-19, the youngest was 30 and the oldest was 86 years old. Seven patients were in their fifties; 12 were in their sixties and 9 were in their seventies. There were 20 males and 17 females. The hospital days ranged from 6 to 60 days with an average of 17 days, lower than the average length of admission of discharged COVID patients which was 28 days. A majority of the deceased patients (25 of the 37, 67.6 %) were ever admitted to an intensive care bed.

Similar to the discharged patients, the most common lung parenchymal finding for deceased patients are ground glass opacities, found in 37 of the 37 (100 %) of these patients. The second and third most common findings are, however, reversed for deceased patients – consolidation (19 out of 37, 51.4 %) is more common than reticular opacities (11 out of 37, 29.7 %) (Table A3).

Among the deceased, 22 (59.5 %) had baseline extent scores that were 6, 7 or 8, implying greater than 50 % lung involvement. None of these patients had a baseline extent score of 0. Six patients had low baseline extent scores of 1 or 2. Thirty-one patients (83.8 %) had worst extent scores of 6, 7 or 8. Twenty-six (70.3 %) had a last extent score of 6, 7 or 8. The worst radiographic extent score of pulmonary opacities among the patients who expired ranged from 4 to 8, with more than three quarters of the patients having a score of 7 (21.6 %) or 8 (54.1 %) in at least one of their CXRs. Seven of the patients had a score of 8 all throughout their admission, with 4–5 CXRs taken (7–12 days), 1 patient had a score of 7 from baseline until death at Day 8, and 6 patients had a combination of 7 or 8 in all of their CXRs.

Unlike that of the discharged patients, 13 out of the 37 deceased patients (35 %) showed worsening radiographic extent scores in the serial follow-up chest x-rays. Only 5 of the deceased patients (14 %) showed improvement while the remaining 19 (51 %) have stable scores over time.

Of the 5 deceased patients that showed apparent radiographic improvement during their course, all still exhibited parenchymal ground-glass opacities in their last chest x-ray. Three out of the 5 had prolonged endotracheal tube placement, while 2 out of the 5 had persistent pleural effusion.

### 3.5. Serial chest x-ray features and comparative findings

The most common lung parenchymal finding in all 785 x-rays reviewed (across all collection date ranges) was the presence of ground glass opacities. For the chest x-rays taken at baseline and admission days 1–3, the second most common finding is that of consolidation, seen in
20.8% and 27.8% of patients, respectively. The third most common finding at baseline and admission days 1–3 was reticular opacities, seen in 16.0% and 16.7%, respectively. However, in nearly all the follow-up chest x-rays taken in the subsequent date ranges, reticular opacities become more common than consolidation, save for admission days 28–30 where the presence of consolidation exceeds the presence of reticular opacities (40% vs 20%, respectively). In addition, the ratio of the total number of the lung parenchymal lesions detected on chest radiography with the remaining admitted population (n) increased from baseline up until admission days 4–6, before more or less declining in the subsequent date ranges, i.e., the ranges of 7–9, 10–12, and 13–15 days (Fig. A3).

The proportion of abnormal findings was significantly higher among patients who expired compared to patients who were discharged for the following: endotracheal tube (68% vs 7.5%, p-value < 0.001) and pleural effusion (70% vs 36%, p-value = 0.0004). On the other hand, the proportion of discharged patients with reticular opacities was significantly higher than the proportion of expired patients (50% vs 30%, p-value = 0.0021) (Table A3).

Expectedly, the average worst radiographic extent score of pulmonary opacities at follow-up CXRs was significantly higher for the patients who expired compared to the patients who were discharged (7.1 vs 5.7, p-value = 0.007). Furthermore, the radiographic extent score of pulmonary opacities was significantly higher for the patients who expired compared to the patients who were discharged on CXRs taken at Day 7–9 (6 vs 4.4, p-value = 0.0011), Day 10–12 (5.9 vs 4.3, p-value = 0.0079) and Day 13–15 (5.5 vs 4.1, p-value = 0.0297) (Fig. A4).

4. Discussion

The study cohort reflects the typical demographic of hospitalized adult patients with COVID-19 – the disease infected older individuals with slight male preponderance [3,7,8]. Majority of patients survive their illness with a 26% mortality rate in our study cohort, which is
within the range of mortality rates noted in previous epidemiologic data [14,15]. Only 5.6 % of the discharged patients were ever admitted in the ICU, as opposed to 67.6 % of the deceased patients – representing a relatively milder infection and/or course for the survivors. It is interesting to note that for this cohort, the discharged patients had longer average length of admission when compared to the deceased patients, contrary to other published epidemiologic data [14]. This suggests that the length of hospital admission in COVID-19 is not a predictor of survival or demise.

Ground-glass opacity (GGO) is the most common lung parenchymal finding at baseline, in the serial follow-up chest x-rays, and in both the discharged and deceased subsets of patients. The other typical baseline lung findings are reticular opacities and consolidation. These are consistent with all previously published data on the radiologic features of COVID-19 pneumonia [1–3,7,8,16]. Reticular opacities are more common for the discharged patients; whereas, consolidation are predominantly observed in the deceased patients. The proportion of discharged patients with reticular opacities was significantly higher than the proportion of expired patients (50 % vs 30 %, p-value = 0.0021). It corroborates a previous study which suggested that the preponderance of consolidation may indicate poor prognosis for COVID-19 [16]. Overall, the lung findings also demonstrate overlap in the imaging features of COVID-19 with pneumonias from other etiologies, including recent coronavirus pneumonias of public health significance, i.e., severe acute respiratory syndrome (2003) and Middle East respiratory syndrome (2012) [2,16]. The poor specificity of the lung opacities of COVID-19 supports the current guidelines which states that chest radiography should not be used as the sole diagnostic test for COVID-19.

In the serial follow-up radiographs, after ground-glass opacities, the other common types of lung lesions detected were consolidation and reticular opacities. An interesting observation is that from baseline to admission days 1–3, consolidation is more common than reticular opacities, peaking in incidence in the latter date range. However, in nearly all the follow-up chest x-rays taken after day 3 of admission, reticular opacities become more common than consolidation, implying a regression of consolidation and replacement by reticular and/or ground-glass opacities. Furthermore, the ratio of the total number of the detectable lung parenchymal lesions with the remaining admitted population (n) increased from baseline up until admission days 4–6, before afterwards. A similar phenomenon is seen in previous studies in the temporal changes of COVID-19 pneumonia, wherein there is an initial progressive stage (1–10 days from symptom onset), followed by a peak/advanced phase (8–15 days from symptom onset), and finally a regression or absorption phase (beyond 14–15 days from symptom onset) [8,17].

It was observed that one-third of the discharged patients (36 of the

Table A1
Radiographic Extent Score [4].

| Normal/No Involvement | < 25 % involved | 25–50% involved | 50–75% involved | >75 % involved |
|-----------------------|-----------------|-----------------|-----------------|---------------|
| 0                     |                 |                 |                 |               |
| 1                     |                 |                 |                 |               |
| 2                     |                 |                 |                 |               |
| 3                     |                 |                 |                 |               |
| 4                     |                 |                 |                 |               |

Note: The scores were taken individually for the right and left lungs, which were then added to derive the radiographic extent score for that particular chest x-ray.

Fig. A4. Distribution of Average Radiographic Extent Scores by CXR collection range.

The Radiographic Extent Scores were significantly different for the Expired and Survived Patients at p < 0.05 level of significance for Days 7–9, 10–12, and 13–15. Note: Beginning at Day 16–18, 30 out of the 37 patients (81 %) in the Expired Group have already died, precluding statistical evaluation of the extent scores between the two groups. After the 36th day of admission, all of the patients in the expired group have already died.
Table A2
Summary table of patient demographics, baseline CXR findings, and clinical outcome.

| Characteristic                  | Summary                  |
|--------------------------------|--------------------------|
| Age                            | 59 ± 12.9 (59.5)         |
| Sex                            |                          |
| Male                           | 93 (64.6)                |
| Female                         | 51 (35.4)                |
| Cases with Normal Baseline CXR | 5 (3.5)                  |
| Cases with Abnormal Baseline CXR| 139 (96.5)               |
| No Pulmonary Opacities at Baseline| 3 (2.1 %)           |
| Present Pulmonary Opacities at Baseline| 136 (94.4 %)   |
| Clinical Outcome               |                          |
| Discharged                     | 107                      |
| Number of days admitted        | 28 ± 13.8 (25)          |
| Expired                        | 37                       |
| Number of days admitted        | 17 ± 12.6 (12)          |
| Lung Parenchyma*               |                          |
| Ground Glass Opacities         | 120 (83.3)               |
| Consolidation                  | 30 (20.8)                |
| Reticular Opacities            | 23 (16)                  |
| Reticulonodular Opacities      | 7 (4.9)                  |
| Nodules / Nodular Opacities    | 4 (2.8)                  |
| Mass / Masses                  | 1 (0.7)                  |
| Predominant Distribution of the Pulmonary Opacities |                |
| Absent / No Opacities          | 8 (5.6)                  |
| Central                        | 12 (8.3)                 |
| Peripherall                    | 12 (8.3)                 |
| Both Central and Peripheral (Diffuse) | 112 (77.8 %)   |
| Radiographic Extent Score of Pulmonary Opacities |              |
| Right                          | 2.8 ± 1.32 (3)          |
| Left                           | 2.6 ± 1.56 (3)          |
| Total                          | 5.4 ± 2.66 (6)          |
| Airways                        |                          |
| Endotracheal Tube              | 16 (11.1)                |
| Tracheal Deviation             | 5 (3.5)                  |
| Bronchiectasis                 | 2 (1.4)                  |
| Pleural Spaces                 |                          |
| Pleural effusion               | 43 (29.9)                |
| Pneumothorax                   | 1 (0.7)                  |
| Pneumohydrothorax              |                          |
| Pleural thickening             | 1 (0.7)                  |
| Pleural calcification / Pleural plaque | 2 (1.4)           |
| Mediastinum and Heart          |                          |
| Lymphadenopathy                | 1 (0.7)                  |
| Mediastinal Widening           | 7 (4.9)                  |
| Mediastinal Mass               | 1 (0.7)                  |
| Cardiomegaly                   | 59 (41)                  |
| Pulmonary congestion           | 7 (4.9)                  |

Table A3
Comparison of Chest Radiographic Results by clinical outcome.

| Result                        | Clinical Outcome |
|-------------------------------|------------------|
| Improved/ Resolved (n = 107)  |                  |
| Expired (n = 37)              |                  |
| p-value                       |                  |
| Lung Parenchyma               |                  |
| Ground Glass Opacities        | 96 (89.7)        |
| Consolidation                 | 35 (32.7)        |
| Reticular Opacities           | 64 (59.8)        |
| Reticulonodular Opacities     | 5 (4.7)          |
| Nodules / Nodular Opacities   | 4 (3.7)          |
| Mass / Masses                 | 2 (1.9)          |
| Radiographic Extent Score of Pulmonary Opacities at follow-up CXRs |          |
| 0                             | 5 (4.7 %)        |
| 1                             | 6 (5.6 %)        |
| 2                             | 7 (6.5 %)        |
| 3                             | 4 (3.7 %)        |
| 4                             | 8 (7.5 %)        |
| 5                             | 8 (7.5 %)        |
| 6                             | 18 (16.8 %)      |
| 7                             | 10 (9.3 %)       |
| 8                             | 41 (38.3 %)      |
| Worst Radiographic Extent Score of Pulmonary Opacities at follow-up CXRs |          |
| 0                             | 5 (4.7 %)        |
| 1                             | 6 (5.6 %)        |
| 2                             | 7 (6.5 %)        |
| 3                             | 4 (3.7 %)        |
| 4                             | 8 (7.5 %)        |
| 5                             | 8 (7.5 %)        |
| 6                             | 18 (16.8 %)      |
| 7                             | 10 (9.3 %)       |
| 8                             | 41 (38.3 %)      |
| Airways                       |                  |
| Endotracheal Tube             | 8 (7.5)          |
| Tracheal Deviation            | 3 (2.8)          |
| Bronchiectasis                | 2 (1.9)          |
| Pleural effusion              | 38 (35.5)        |
| Pneumothorax                  | 1 (0.9)          |
| Pneumohydrothorax             | 0 (0)            |
| Pleural thickening            | 2 (1.9)          |
| Pleural calcification / Pleural plaque | 2 (1.9)   |
| Mediastinum and Heart         |                  |
| Lymphadenopathy               | 1 (0.9)          |
| Mediastinal Widening          | 3 (2.8)          |
| Mediastinal Mass              | 1 (0.9)          |
| Cardiomegaly                  | 45 (42.1)        |
| Pulmonary congestion          | 8 (7.5)          |

Note: For Abnormal baseline CXR findings, the frequency and percentage of patients with the finding present is shown.

107 discharged patients) were sent home despite having radiographic extent scores of 5 and above. The predominant lung lesions in the pre-discharge chest x-rays of these patients are reticular opacities, followed by ground-glass opacities. This may be due to the fact that present clinical guidelines recommend a symptom-based criteria for the discharge of patients with no need for a RT-PCR test or chest radiography [3]. These findings support the aforementioned hypothesis that lung findings in COVID-19 gradually regress to reticular opacities in the absorption phase of the disease [8,17]. Furthermore, it may also suggest that the gradual appearance and predominance of reticular opacities in the chest x-ray may correlate with resolving symptoms for COVID-19. A caveat is that reticular opacities in chest x-rays usually represent diseases of the pulmonary interstitium, and correspond to chest CT findings of interstitial fibrosis, interlobular septal thickening and intralobular lines, among others [13].

Unlike previous published data wherein lung lesions are typically peripheral in distribution and predominantly involving the lower lung zones, the baseline lung lesions in our cohort involve both the central and peripheral portion of the lungs with bilateral patchy/scattered and diffuse zonal locations [1–3,7,8,16]. It may indicate that the lung opacities in Filipinos with COVID-19 pneumonia display a different chest x-ray manifestation than those previously reported from other countries. Another explanation is that since the study site is a COVID-19 referral center, perhaps the subset of the total population sampled may be skewed towards those having more severe and extensive disease. Either way, this finding complicates the interpretation of chest x-rays in our subset of patients because the bilateral patchy distribution and lack of peripheral predominance of the lung lesions make them indistinguishable from other infectious disease of the lungs [18].

The mean baseline radiographic extent score was not significantly different between those who died and those who were discharged. However, the average worst radiographic extent score of pulmonary opacities at follow-up CXRs was significantly higher for the patients who expired compared to the patients who were discharged (7.1 vs. 5.7, p-value = 0.007), with the worst extent score for deceased patients
indicating severe/extensive lung involvement. This finding is consistent with previous data wherein a high chest x-ray severity score is predictive of adverse patient outcomes, including endotracheal intubation and prolonged hospitalization [8,19]. Furthermore, the radiographic extent score of pulmonary opacities was significantly higher for the patients who expired compared to the patients who were discharged on CXRs taken at Day 7–9, Day 10–12, and Day 13–15. Hence, it can be surmised that beginning at seven (7) days from admission, a persistently severe radiographic extent score (greater than 7) may be a predictor of mortality for patients admitted with COVID-19.

As for the non-parenchymal findings, it was noted that endotracheal intubation (68% vs 7.5%, p-value < 0.001) and the presence of pleural effusion (70% vs. 36%, p-value = 0.0004) were significantly higher for patients who expired from COVID-19. Intubation and mechanical ventilation of patients are reserved for critically-ill patients (e.g., patients with COVID-19 acute respiratory distress syndrome), and it is therefore not surprising to observe them more in the non-survivors [3]. The presence of pleural effusion is not typical for coronavirus pneumonia [16]. However, it was found out that in a previous study that pleural effusion is seen in patients with refractory disease, i.e., those with no clinical/radiologic remission despite prolonged admission [20]. It was hypothesized that it denotes more marked inflammatory response of the lungs (i.e., cell-mediated immunity and cytokine storm), resulting in capillary leakage and pulmonary edema [3,20]. This may explain the preponderance of pleural effusion in the patients who died.

This study has several limitations. First, in order to manage the limited hospital capacity and health human resource, the present guidelines recommend hospital admission for patients with moderate, severe, and critical COVID-19 infection. It relegates mild cases (i.e., patients with no signs of pneumonia or hypoxia) for home or facility isolation [3]. Hence, the subset of the population we have sampled may be skewed towards those with more severe disease and the findings may not be generalizable to the general population. Furthermore, the investigators were not granted full access to the patient records and thus, no comment can be made on the co-morbidities and other relevant clinical findings of the patients.

5. Conclusions
The most common lung parenchymal findings are ground-glass opacities. Reticular opacities are more common in the discharged patients while consolidation is more common in the deceased patients, suggesting that conversion of opacities from ground glass to consolidation to reticular is a sign of improvement. The distribution of lung opacities in this cohort is bilateral and diffuse/patchy that involves both the central and peripheral zones, unlike the findings in other countries. Age, baseline extent scores, worst extent scores and length of hospital admission did not predict outcome in this cohort. The findings of endotracheal intubation, pleural effusion, and persistently elevated chest radiographic extent scores are directly correlated with patient mortality. Hence, serial chest radiography is a useful tool in monitoring COVID-19 for hospitalized adult patients. The need for long-term follow-up imaging for patients who recovered from COVID-19, the emergence of new variants of SARS-CoV-2, and the potential impact of COVID-19 vaccines in the imaging features of the disease are potential avenues for further research.

Ethical statement
A retrospective, cross-sectional study design was utilized using available patients’ medical and imaging records. There was no direct patient participation, contact, or interaction. This study was granted approval by the University of the Philippines Manila Research Ethics Board prior to initiation.

A waiver of informed consent was granted for this study.

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CRediT authorship contribution statement
Julian A. Santos: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Visualization, Project administration, Writing - original draft, Writing - review & editing. Johanna Patricia A. Canal: Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Validation, Supervision, Writing - review & editing.

Declaration of Competing Interest
The authors report no declarations of interest.

Appendix A

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