COVID-19: high-resolution computed tomography findings in the first 64 patients admitted to the Hospital of Cremona, the epicentre of the pandemic in Europe

Vittorio Sabatino1A,B,C,D,E,F*, Pietro Sergio1A,B,C,D,E,F*, Margherita Muri1B,D, Ilaria Zangrandi1B,D, Giuseppe Voltini1A,B,D, Giancarlo Bosio1A,D, Monia Betti2A,D, Francesca Baglivo1A,B,D,F, Enrico Martinelli1A,D, Angelo Pan1A,D, Matteo Giorgi Pierfranceschi1A,D, Antonio Corvino3E,F, Laura Romanini1A,B,C,D,E,F,G

1Radiology Department, Hospital of Cremona – Azienda Socio Sanitaria Territoriale di Cremona, Italy
2Pulmonology Department, Hospital of Cremona – Azienda Socio Sanitaria Territoriale di Cremona, Italy
3Infectious Diseases Department, Hospital of Cremona – Azienda Socio Sanitaria Territoriale di Cremona, Italy
4General Internal Medicine Department, Hospital of Cremona – Azienda Socio Sanitaria Territoriale di Cremona, Italy
5Department of Motor Science and Wellness, University of Naples “Parthenope”, Italy

Abstract

Purpose: In December 2019, a new coronavirus (SARS-CoV-2) was identified as being responsible for the pulmonary infection called COVID-19. On 21 February 2020, the first autochthonous case of COVID-19 was detected in Italy. Our goal is to report the most common chest computed tomography (CT) findings identified in 64 patients, in the initial phase of COVID-19.

Methods: Sixty-four chest high-resolution computed tomography (HRCT) examinations performed at the Radiology Unit of the Hospital of Cremona, from 22 to 29 February 2020, of 64 patients during first week of hospitalization for COVID-19 were retrospectively evaluated. All cases were confirmed by real-time RT-PCR for SARS-CoV-2. Image analysis was independently conducted by 2 radiologists with 10 years and 1 year of experience in chest imaging. The inter-observer agreement was obtained by applying a Cohen’s κ test.

Results: The average age of patients was 67.1 years (± 12.2); men 42 (66%). HRCT was performed on the 5th (± 1.5) day of hospitalization. More frequently, the initial CT changes of the lung show more or less extensive areas of ground-glass, as single pattern or with parenchymal consolidations. Coronavirus lung involvement appears very frequently multi-lobar, bilateral, and it concerns both subpleural and central regions. An excellent agreement (κ: 0.88-1, CI: 0.79-1.01, p < 0.05) concerning CT findings between the 2 operators was reached.

Conclusions: Our data suggest that detection of the most frequent pulmonary CT-scan changes, in the early stages of COVID-19, can be performed, with excellent agreement, among readers with different experience, and consequently attribute their exact diagnostic value, in an appropriate clinical and environmental exposure setting.

Key words: COVID-19, SARS-CoV-2, coronavirus, HRCT, pulmonary infection, epidemic.

Introduction

In December 2019, a new coronavirus (SARS-CoV-2) was identified as being responsible for the pulmonary infection called COVID-19 (coronavirus disease 2019) [1-5]. On 21 February 2020, the first autochthonous case of coronavirus infection (COVID-19) was detected in Italy in a 38-year-old man who arrived in an emergency room in...
the Lombardy region in the Hospital of Codogno (30 km away from Cremona) with fever and respiratory symptoms.

Approximately 7 days after the first infection, the Hospital of Cremona (Lombardy) was treating about 109 coronavirus patients (2019-nCoV). Symptomatic patients (COVID-19) in almost all cases had non-productive cough, fever, and respiratory failure. In the first week of hospitalization, about 65 patients underwent high-resolution computed tomography (HRCT) of the chest. Chest computed tomography (CT) investigations of the chest were necessary, especially in cases of inconsistency between the patient’s clinical data and the findings of the corresponding chest X-rays.

Our aim is to present the most common findings identified in 64 HRCTs of the chest related to 64 different patients with COVID-19, in the initial stage of infection.

**Material and methods**

Our institutional review board (IRB) waived written informed consent for this retrospective study, not recognizing any potential risks of violation of patient confidentiality.

Sixty-four chest HRCT examinations, performed at the Radiology Unit of the tertiary Hospital of Cremona, from 22 February to 29 February 2020, in 64 patients during the first week of hospitalization for COVID-19, were retrospectively evaluated. All cases were confirmed by real-time RT-PCR for SARS-CoV-2. The analysis of the chest CT exams was independently conducted by 2 radiologists with 10 years (Reader A) and 1 year (Reader B) of experience in chest imaging.

A standard nomenclature defined by the Fleischner Society glossary [6] was used for CT findings: crazy paving, ground glass, consolidation, and perilobular pattern. A semi-quantitative scoring system was used to quantitatively estimate the pulmonary involvement. Lung involvement was classified mild, moderate, and severe. Mild involvement was when the sum of the parenchymal abnormalities in both lungs was equal to or less than the volume of the respective upper segment of the Right Upper Lobe (RUL). Moderate involvement was when the sum of the parenchymal abnormalities in both lungs was greater than the volume of the respective upper segment of the RUL, but equal to or less than the overall RUL volume. Severe involvement was if the sum of the parenchymal abnormalities in both lungs was greater than the RUL volume.

The distribution of the findings was recorded as subpleural (involving the peripheral lung zones, including perifissural zones, less than 1 cm from pleural surface), central (if more than 1 cm from the pleural surface, including perifissural zones), or combined (when subpleural and central lesions coexisted). The number of lung lobes involved was recorded: right upper lobe (RUL), left upper lobe (LUL), right middle lobe (RML), right lower lobe (RLL), and left lower lobe (LLL), and we considered linguula as different lobes for better classification. The presence or absence of pleural effusion was also recorded.

The inter-observer agreement was obtained by applying a Cohen’s κ test (0: no concordance, 1: maximum concordance). The results are reported with 95% confidence interval, and a p-value <0.05 was considered statistically significant. Data were analysed with Statistical Analysis System (IBM SPSS Statistics v. 23).

**Results**

The average age of patients undergoing HRCT of the chest was 67 ± 12 years (range: 32-85 years). Men totalled 42 (66%) and women 22 (34%). On average the CT scan examination was performed on the 5th ± 1.5 day of hospitalization (Table 1).
Data relating to Reader A

Ground glass opacities were identified in 63 patients (98.4%), parenchymal consolidations in 38 patients (59.3%), perilobular pattern in 17 patients (26.5%), and crazy paving pattern in 4 patients (6.2%). The most frequent association between the different patterns was the combination of ground glass and consolidation in 37 patients (57.8%) (Figures 1 and 2). On average 5.3 lobes per patient were involved. Central distribution of the alterations was identified in 50 patients (78.1%), subpleural distribution in 58 patients (90.6%), and the combination of central and subpleural distribution in 44 patients (68.7%) (Figure 3). The extent was judged mild in 15 patients (23.4%), moderate in 22 patients (34.3%), and severe in 27 patients (42.1%). Pleural effusion was identified in 7 patients.

Data relating to Reader B

Ground glass opacities were identified in 62 patients (96.8%), parenchymal consolidations in 39 patients (60.9%), perilobular pattern in 12 patients (18.7%), and crazy paving pattern in 6 patients (9.3%). The most frequent association between the different patterns was the combination of ground glass and consolidation in 37 patients (57.8%). On average 5.4 lobes per patient were involved. Central distribution of the alterations was identified in 45 patients (70.3%), subpleural distribution in 62 patients (96.8%), and the combination of central and subpleural distribution in 43 patients (67.1%). The extent was judged mild in 10 patients (15.6%), moderate in 20 patients (31.2%), and severe in 34 patients (53.1%). Pleural effusion was identified in 7 patients (Table 2).

An excellent agreement (Cohen’s κ: 0.88-1, CI: 0.79-1.01, p < 0.05) was found between the 2 operators concerning CT findings (Table 3).

Discussion

Numerous experiences from endemic areas of China suggest that chest CT scan is a vital tool in the diagnostic algorithm for patients with suspected COVID-19 infection.
sunquent in the male population (Table 1), as described by
tienty failure. Chest CT-scan investigations were necessary,
infection underwent HRCT of the chest. Fifty-eight pa-
tory case with suspected or confirmed COVID-19 [11]. Integrated
mographic involvement (COVID-19) is very fre-
more frequently, the initial CT findings of the lung
12). In particular, it is useful as a preliminary study in
formatum extent of the disease, and in assessing the sub-
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for the risk stratification of patients
clude that no alterations such as centrilobular
lar and mild.
A further element of interest is the degree of pulmo-
that have identified a semi-quantitative criterion of lung disease extension, in addition to clinical signs and
f for the risk stratification of patients
hese were found. There was infrequent evidence of pleural effusion, and when present, it was commonly bi-
pmonary involvement and about 42% of our patients had se-
the inter-observer concordance between the
mological consolidations and ground-glass areas may also show areas of sparing lobular morphology, and
on the nature of the highlighted lesions, we
clude whether the degree of initial extension of the disease
orpleural airways, typical data of inflammatory involvement of small airways, of bronchiolitis and/or parenchymal type
eg. acinar), were found. There was infrequent evidence of pleural effusion, and when present, it was commonly bi-
paringal consolidations and ground-glass areas
such alterations [14].
We can add that no alterations such as centrilobular
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is of COVID-19 [11]. Integrated imaging for COVID-19 is the best key to reaching a confident diagnosis [12].
A further element of interest is the degree of pulmonary
n are represented by more or less extensive areas of ground
glass as a single pattern or in association with parenchymal consolidations. Infrequent patterns are represented by
crazy paving and peri-lobular changes. Such patterns, in
our experience, are always in association with ground glass areas and/or consolidations, and never dominant pattern. The parenchymal consolidations and ground-glass areas may also show areas of sparing lobular morphology, and their zonal arrangement does not respect a sub-segmental, segmental, or lobar anatomical distribution.
With regard to the nature of the highlighted lesions, we interpret the findings as diffuse alveolar damage (DAD) or acute fibrinous and organizing pneumonia (AFOP) alterations. We prefer these terms in the radiological description, rather than ARDS, considering ARDS as the clinical syndrome associated with such alterations [14].

In our Radiology Department, during the first week of hospitalization, 64 symptomatic patients with COVID-19
fection underwent HRCT of the chest. Fifty-eight patients out of 64 had simultaneous fever, cough, and respiratory failure. Chest CT-scan investigations were necessary, especially in cases of inconsistency between the patient's clinical data and the findings of the corresponding chest X-rays. These data were due to the low sensitivity of the chest X-ray in the detection of interstitial alterations (e.g. ground-glass), and the rapid progression of pulmonary parenchymal findings.

The incidence of COVID-19 appears to be more frequent in the male population (Table 1), as described by Sun et al. [13]. Moreover, our data allow us to state that coronavirus lung involvement (COVID-19) is very frequently multi-lobar, bilateral, and affects both the subpleural and central regions of the lungs. Subpleural involvement is moderately more frequent than central involvement (Table 2).

More frequently, the initial CT findings of the lung are represented by more or less extensive areas of ground glass as a single pattern or in association with parenchymal consolidations. Infrequent patterns are represented by

total 7/64 (10.9%) 7/64 (10.9%)

<table>
<thead>
<tr>
<th>Lung involvement</th>
<th>Reader A</th>
<th>Reader B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleural effusion</td>
<td>7/64 (10.9%)</td>
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</table>

Table 3. Inter-observer agreement between first and second operator. Kappa – Cohen's κ, CI – confidence intervals. P – statistical significance < 0.05

<table>
<thead>
<tr>
<th>Inter-observer agreement</th>
<th>Kappa</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground-glass</td>
<td>0.99</td>
<td>0.97-1.01</td>
</tr>
<tr>
<td>Consolidation</td>
<td>0.87</td>
<td>0.80-0.93</td>
</tr>
<tr>
<td>Perilobular</td>
<td>0.86</td>
<td>0.79-0.92</td>
</tr>
<tr>
<td>Crazy paving</td>
<td>0.99</td>
<td>0.97-1.01</td>
</tr>
<tr>
<td>Distribution</td>
<td>0.88</td>
<td>0.82-0.94</td>
</tr>
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<td>0.88</td>
<td>0.82-0.94</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>1</td>
<td>1</td>
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</tbody>
</table>

Table 2. High-resolution computed tomography (HRCT) lung findings

<table>
<thead>
<tr>
<th>HRCT findings</th>
<th>Reader A</th>
<th>Reader B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground-glass</td>
<td>63/64 (98.4%)</td>
<td>62/64 (96.8%)</td>
</tr>
<tr>
<td>Consolidation</td>
<td>38/64 (59.4%)</td>
<td>39/64 (60.9%)</td>
</tr>
<tr>
<td>Perilobular</td>
<td>17/64 (26.6%)</td>
<td>12/64 (18.7%)</td>
</tr>
<tr>
<td>Crazy paving</td>
<td>4/64 (6.2%)</td>
<td>6/64 (9.4%)</td>
</tr>
<tr>
<td>Ground-glass and consolidation</td>
<td>37/64 (57.8%)</td>
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<tr>
<td>Distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>50/64 (78.1%)</td>
<td>45/64 (70.3%)</td>
</tr>
<tr>
<td>Subpleural</td>
<td>58/64 (90.6%)</td>
<td>62/64 (96.8%)</td>
</tr>
<tr>
<td>Combined</td>
<td>44/64 (68.7%)</td>
<td>43/64 (67.1%)</td>
</tr>
<tr>
<td>Localization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of involved lobes</td>
<td>5,3/6 (88.3%)</td>
<td>5,4/6 (90.0%)</td>
</tr>
<tr>
<td>Lung involvement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>15/64 (23.4%)</td>
<td>10/64 (15.6%)</td>
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<tr>
<td>Moderate</td>
<td>22/64 (34.3%)</td>
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</tr>
<tr>
<td>Severe</td>
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Pleural effusion 7/64 (10.9%) 7/64 (10.9%)

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gists, making HRCT not only sensitive but also relatively objective.

We are aware that our sample is too small to make exhaustive judgements. Moreover, among the descriptive limits of our experience it must be underlined that a mixed ground glass-consolidation pattern was recorded in the same way as a case where a ground glass area and a consolidation area were in 2 distinct lung areas. Furthermore, multiple and focal alterations, distributed peripherally and centrally, were recorded in the same way as a diffuse extension of disease (e.g. lobar). Finally, when present, atelectasis areas were recorded as consolidations.

**Conclusions**

We report the data from our experience to show the most common pulmonary HRCT patterns of COVID-19 presentation at an early stage. In addition, we would like to emphasize how the detection of such patterns can be performed with excellent agreement by readers with different experience, and thus assign their exact diagnostic value in an appropriate clinical and environmental exposure setting.

**Conflict of interest**

The authors report no conflict of interest.

**References**