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CT appearance in the 330 patients with coronavirus disease 2019 (COVID-19) in Serbia

CT karakteristike bolesti koronavirus 2019 (COVID-19) kod 330 bolesnika lečenih u Srbiji

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Abstract

Background/Aim. The corona virus disease 2019 (COVID-19) primarily affects the respiratory system, so radiological diagnosis has been shown to be necessary. Chest computed tomography (CT) is to be shown the best modality in suspected COVID-19 cases for initial evaluation because CT findings may be present before the onset of symptoms. The aim of this study was to show different CT imaging features or patterns in COVID-19 patients with a different time course and disease severity. **Methods.** This prospective cohort study analysed 330 patients (the average age was 52.37 ± 15.36) with confirmed COVID-19 via laboratory testing. During hospitalization, all patients included in the study underwent chest CT in order to assess the extent of changes in their lungs. COVID-19 patients, with a different time course and disease severity, were classified into four categories: lung, bronchial, pleural and mediastinal changes. Based on the time interval between the onset of symptoms and performed CT scan, all patients were divided into three groups: group 1 (CT scans done ≤ 1 week after symptom onset); group 2 (from > 1 to 2 weeks after symptom onset); group 3 (from > 2 weeks after symptom onset). In order to monitor the distribution of changes in the lungs more accurately, bilateral lungs were divided into 12 'lung' zones. Each zone was assigned a CT score. Total severity score was calculated by summing the scores for each zone. **Results.** In 93.6% patients with COVID-19, the CT findings were positive. About 92.1% patients had multiple lesions. The lesions were bilateral in 87.6% of patients, localized both peripheral and centrally in 63.3% of patients, and occurred more frequently in posterior areas (93%), as well as in lower lung zones (91.2%). The average total severity score was 11.00 (7.00–16.00). The most common CT findings in all patients were the ground-glass opacities (97.7%), reticular pattern (91.3%), consolidation (71.5%) and fibrotic streaks (63.8%). In the group 1, changes on CT were found in 80.0%, in the group 2 in 95.0%, and in the group 3 in 99.4% of the patients. **Conclusion.** CT is proven to be a very important diagnostic method in COVID-19 patients, and together with clinical and laboratory findings, gives a complete picture of the patient's condition and contributes significantly to decision-making for further treatment.

Key words:
covid-19; lung; diagnosis; organ dysfunction scores; pneumonia; severity of illness index; tomography, x-ray computed

Apstrakt

Uvod/Cilj. Bolest koronavirus 2019 (COVID-19) primarno zahvata respiratorni sistem, tako da se radiološka dijagnostika pokazala neophodnom. Kompjuterizovana tomografija (CT) grudnog koša pokazala se kao najbolji modalitet za inicijalnu procenu osoba sumnjivih na COVID-19, pošto CT nalaz može biti pozitivan i pre pojave simptoma. Cilj ove studije bio je da se prikažu različite CT karakteristike obolelih od COVID-19, sa različitim vremenskim tokom i težinom bolesti. **Metode.** Sprovedena je prospektivna kohortna studija na 330 bolesnika (prosečne starosti 52,37 ± 15,36) sa dijagnozom COVID-19, potvrđenom putem laboratorijskog testiranja. Tokom hospitalizacije, svim bolesnicima uključenim u studiju urađen je CT pregled grudnog koša u cilju procene proširenosti promena u plućima. Promene na CT snimcima podeljene su u četiri kategorije: plućne, bronhijalne, pleuralne i medijastinalne promene. Na osnovu vremenskog intervala od pojave simptoma do CT pregleda, bolesnici su bili podeljeni u tri grupe: prva grupa (≤ 7 dana); druga grupa (7–14 dana); treća grupa (> 14 dana). U cilju što preciznijeg praćenja distribucije

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lezija u plućima, pluća su podeljena na 12 'plućnih' zona. Svakoj zoni je dodeljen CT skor. *Total severity score* bio je izračunat kao suma skorova pojedinih zona. **Rezultati.** Kod 93,6% obolelih od COVID-19, CT nalaz je bio pozitivan. Oko 92,1% bolesnika imalo je više lezija. Lezije su bile bilateralne kod 87,6% bolesnika, periferno i centralno lokalizovane kod 63,3% bolesnika, a češće su se javljale u posteriornim segmentima (93%), kao i u donjim plućnim zonama (91,2%). Prosečan *Total severity score* bio je 11,00 (7,00–16,00). Najčešći CT nalaz je bila opacifikacija po tipu „mlečnog stakla" (97,7%), retikularna šara (91,3%), konsolidacija (71,5%) i fibrozne trake (63,8%). Promene na CT snimku nađene su kod 80.0% bolesnika iz prve grupe, kod 95.0% iz druge grupe i kod 99.4% iz treće grupe. **Zaključak.** CT se pokazao kao veoma važna dijagnostička metoda kod bolesnika sa COVID-19 i zajedno sa kliničkim i laboratorijskim nalazima daje potpunu sliku stanja bolesnika čime značajno utiče na donošenje odluka o daljem lečenju.

Ključne reči:
covid-19; pluća; dijagnoza; skorovi, disfunkcija organa; pneumonija; bolest, indeks težine; tomografija, kompjuterizovana, rendgenska

Introduction

Several cases of pneumonia with an unidentified origin occurring in Wuhan City, the capital of Central China's Hubei Province were reported to the World Health Organization (WHO) on December 31, 2019. The cases are epidemiologically related to Huanan Seafood Wholesale Market [1]. The viral origin of the mentioned pneumonias was soon determined, and on January 7th, 2020 the causative agent was identified as the 2019 novel coronavirus (2019-nCoV), later this was renamed to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [2]. The WHO declared the outbreak of a global health emergency on January 30th, 2020 [3]. On 12th February 2020, WHO named the disease caused by SARS-CoV-2 as coronavirus disease 2019 (COVID-19). Finally, on 11th March 2020, WHO formally announced that COVID-19 was a pandemic [4]. By the end of October 2020, the disease has spread to almost all countries with about 50,000,000 patients and about 1,000,000 deaths and the number of patients and deaths are still increasing.

The real- time reverse transcription polymerase chain reaction (rRT-PCR) of viral nucleic acid is regarded as a reference standard in COVID-19 diagnosis. The rRT-PCR test for COVID-19 is believed to have high specificity but the sensitivity has been reported to be as low as 60–70% [5, 6].

The disease primarily affects the respiratory system, so radiological diagnosis has been shown to be necessary. Chest radiographs are the first-line imaging test for identifying pneumonia, but are of little diagnostic value in the early stages. In the intermediate to advanced stages of COVID-19 chest radiographs may show a progression of radiological features. At the same time chest computed tomography (CT) is to be shown the best modality in suspected COVID-19 cases for initial evaluation because CT findings may be present before the onset of symptoms [7, 8]. In a number of cases with an initial false-negative rRT-PCR test, some authors have reported CT findings that have proved to diagnose with sensitivity of 98% [5]. Chest CT has also significance in monitoring disease progression and therapeutic efficacy. The predominant CT findings of COVID-19 are bilateral, peripheral, posterior and basal predominant ground-glass opacity (GGO) with or without consolidation [9, 10].

Studies so far suggest a possible association between CT findings and the severity of the clinical features [11]. The problem is still asymptomatic patients and ones with an atypical clinical features. Adequate interpretation of CT findings, typical and atypical CT characteristics, as well as the evolution of CT findings are essential for effective patient management and treatment. Therefore, the aim of this study was present a wide range of CT features in patients with COVID-19, all with the aim of a better understanding of them.

Methods

The principles of the International Conference on Harmonization (ICH) Good Clinical Practice, the Declaration of Helsinki and national and international ethical guidelines were strictly followed during this study. The approval from the Ethics Committee of the University Hospital "Dr. Dragiša Mišović – Dedinje", Belgrade, Serbia was obtained (Nº 01-7661).

This prospective cohort study analysed 330 patients (consecutive sampling) with confirmed COVID- 19 via laboratory testing with rRT-PCR of respiratory secretions obtained by nasopharyngeal or oropharyngeal swabs, which were treated in the University Hospital "Dr. Dragiša Mišović – Dedinje", Belgrade, Serbia, between March and May 2020. During hospitalization, all patients included in the study underwent chest CT in order to assess the extent of changes in their lungs. The patient and clinical data including age, gender, comorbidities, symptoms, date of onset of symptoms, laboratory examination results were collected for the entire group and analysed.

CT protocol

All CT scans were obtained using the Canon (former Toshiba), Aquillion One (TSX-301C), 320 row MDCT System (Canon, Tokyo, Japan). Scans acquisition were done from the level of the thoracic entrance to the inferior level of the costophrenic angle with patient in a supine, arms raised, head forward position and with breath-holding manner during end inspiration. Unenhanced CT scans were obtained for all patients. The following parameters were used: tube voltage 120 kV with automatic tube current modulation, slice thickness 1.0 mm. In pregnat women, a radiation shield was used over the gravid uterus.

Chest CT image analysis

All CT images were reviewed by two experienced radiologists with extensive experience in thoracic imaging, on a diagnostic workstation (Vitrea extend-Vital, Canon, Tokyo, Japan) with multiplanar reconstruction (MPR) tools. The images were viewed in the lung window settings (width, 1,600 HU; level, 400 HU) and mediastinal (soft tissue) window settings of width, 380 HU; level, 40 HU. All discrepancies were resolved by consensus.

Since chest CT images could show different imaging features or patterns in COVID-19 patients with a different time course and disease severity [12–15], we classified them into four categories: lung, bronchial, pleural and mediastinal changes (Figures 1 and 2).

Based on the time interval between the onset of symptoms and the CT scan, all patients were divided into three groups: group 1 (CT scans done ≤ 1 week after symptom onset); group 2 (CT scans done > 1 to 2 weeks after symptom onset); group 3 (CT scans done > 2 weeks after symptom onset).

In order to monitor the distribution of changes in the lungs more accurately, bilateral lungs were divided into 12 ‘lung’ zones, as follows: each side of the lung was divided into two areas – the anterior and posterior area (the boundary between these two regions was represented by an imaginary vertical line passing through the middle of the diaphragm in the sagittal plane); after that each area was divided into three zones – above the carina is the upper zone, the middle zone is from the carina to the inferior pulmonary vein, and below the inferior pulmonary vein is the lower zone. Each zone was assigned a CT score which was based on the following criteria: no involvement – score 0, 1% to less than 25% – score 1, 25% to less than 50% – score 2, 50% to less than 75% – score 3 and more than 75% – score 4. Total severity score was calculated by summing the scores for each zone, with maximum possible score of 48.

Fig. 1 – Lung changes on chest computed tomography (CT) in coronavirus disease 2019 (COVID-19) patients. GGO – ground-glass opacity.

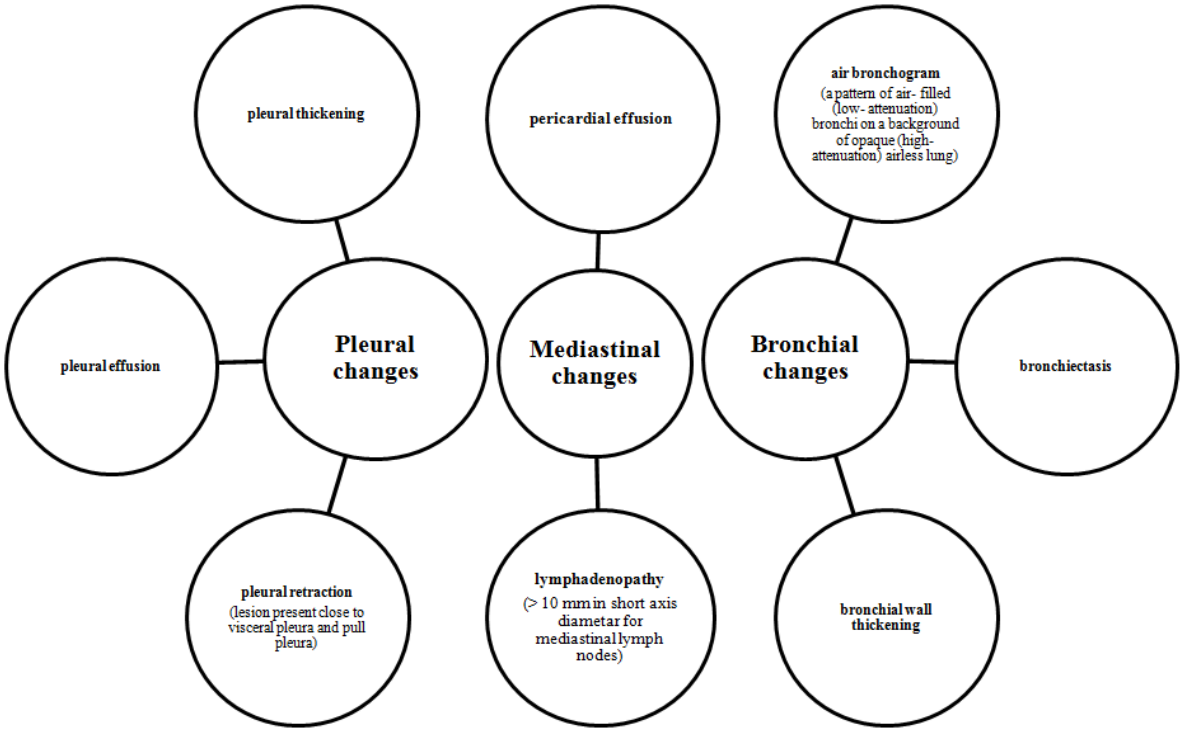

Fig. 2 – Pleural, bronchial and mediastinal changes on chest computed tomography (CT) in coronavirus disease 2019 (COVID-19) patients.

Statistical analysis

Based on standard statistical parameters [study power 80% (0.85), probability of α error 0.05, two-way testing, equal group sizes], to find a significant difference in the value of CT score between different parts of lungs in patients with COVID-19 infection (CT score was 3.0 ± 3.4 in the upper lung, and 4.5 ± 3.8 in the middle lung) [15], the required sample size was calculated by *t*-test for independent samples, using G*Power 3.1, from 103 patients per group (effect size 0.42). However, it was planned to include a total of 110 patients in each of the three groups, as a possible loss of 10% per group was included.

Statistical analysis was conducted using an IBM SPSS Statistics 19.0 computer program (IBM, USA, 2011). All continuous variables were described in the form of the mean ± standard deviation or median [interquartile range (IQR)] values. The categorical variables were expressed as percentages and examined using the χ^2-test; the Yates's correction for continuity was with a 2 × 2 contingency table. Comparisons of parametric variables between 2 groups were performed by independent samples *t*-test and non-parametric variables were tested with the Mann-Whitney *U* test. Comparisons of non-parametric variables between more than 3 groups were performed with the Kruskal-Wallis test. The normality distribution of data was tested by the Kolmogorov-Smirnov test. All the analyses were evaluated at the level of statistical significance of $p < 0.05$. Missing or incomplete data were not used in the statistical analysis.

Results

In our study the total number of patients with COVID-19 was 330, male sex was dominant (Table 1). The average age of all patients was 52.37 ± 15.36 (male: 52.76 ± 15.11; female: 51.60 ± 15.87; Independent samples *t*-test, $p = 0.518$). All patients had symptoms at the onset of the disease, of which the most common was fever, present in 86.4% patients. Arterial hypertension was the most common comorbidity (37.6% patients). Also, we treated 9 (2.7%) pregnant women, all in late fetal period (over 25 weeks of gestation).

Blood tests were performed for all 330 patients (Table 1). The main haematological findings we found in our patients were a decreased erythrocytes count (20.3%) and a decreased haemoglobin (21.8%). The largest number of patients had a normal leukocyte count, and we found an increased monocyte count in 67.9% of patients. As for the other laboratory findings, increased ferritin was found in 70.9%.

The CT finding was positive in 309 out of 330 patients (93.6%) with COVID-19. About 6.5% of the COVID-19 patients with clinical positive findings had no

Table 1

Demographic and clinical characteristics of the patients with coronavirus disease 2019 (COVID-19)

Characteristic	Patients
Gender	
male	219 (66.4)
female	111 (33.6)
Age (years)	52.37 ± 15.36
Symptom	
fever	285 (86.4)
fatigue	225 (68.2)
shortness of breath	128 (38.8)
coughing and sputum	244 (73.9)
muscle pain	181 (54.8)
digestive symptoms (diarrhea, abdominal pain, vomiting)	51 (15.5)
other (chest pain, headache, disorientation, taste and smell disorder, pain in throat)	72 (21.8)
Comorbidities	
arterial hypertension	124 (37.6)
other heart diseases	16 (4.8)
obesity	98 (29.7)
diabetes	32 (9.7)
chronic renal failure	22 (6.7)
stroke	13 (3.9)
other neurological disease	3 (0.9)
pulmonary diseases (asthma, chronic obstructive pulmonary disease, chronic bronchitis)	22 (6.7)
other (anemia, cholangitis, benign hypertension of prostate, dementia, Hashimoto thyroiditis, depression, carcinomas, sarcoidosis etc.)	90 (27.3)
Other conditions	
pregnancy	9 (2.7)
Selected laboratory test findings	
decreased erythrocytes	67 (20.3)
decreased hemoglobin	72 (21.8)
leukocyte count: decreased / increased	30 (9.1)/22 (6.7)
lymphocyte count: decreased / increased	115 (34.8)/18 (5.5)
neutrophil count: decreased / increased	35 (10.6)/95 (28.8)
eosinophil count: decreased / increased	117 (35.5)/ 6 (7.9)
monocyte count: decreased / increased	1 (0.3)/224 (67.9)
increased erythrocyte sedimentation rate	117 (35.5)
increased serum procalcitonin	19 (5.8)
increased c- reactive protein	208 (63.0)
increased lactate dehydrogenase	124 (37.6)
increased ferritin	234 (70.9)

Results are expressed as number (%) or mean ± standard deviation (SD).

CT pathological findings. About 92.1% had multiple lesions and lesions were most often bilateral (Table 2, Figures 3–5). Most patients had both a peripheral and central localization of lesions at the same time (63.3%) (Figures 3 and 4). If we look at the distribution of lesions by lung zones, then we see that the posterior areas were more often affected (93%). It is also noticeable that changes occurred more often in lower lung zones (91.2%) (Table 2).

The average Total severity score in patients, in whom CT changes were found in the lungs (309), was 11.00 (7.00–16.00). The average Total severity score was significantly higher in patients with multiple rather than with single lesions, as well as in bilateral versus unilateral lesion distribution. Also, the Total severity score was higher in patients with peripheral and central lesion distribution, compared with patients with only peripheral or central lesion distribution (Table 2).

In relation to the time period after the onset of symptoms, the scan was usually done after 14 days (47% of the patients). Slightly less was done between the seventh and 14th day (30.3%) and least amount in the first 7 days following the onset of the disease symptoms (22.7%). When the time interval was monitored between onset of symptoms and the CT scan, it was noticed that in the group 1 changes on CT were found in 80.0% of the patients, in the group 2 in 95.0% of the patients, and in the group 3 in 99.4% of the patients. It should be noted that significant differences were found in the time distribution of individual CT signs. As the most common CT finding in all patients, ground-glass opacities (GGO) was observed in 97.7%, reticular pattern in 91.3%,

Table 2

Distribution of computed tomography (CT) pathological findings (lesion distribution) in the patients with coronavirus disease 2019 (COVID-19)

Parametres	Number of patients	CT score	*p*-value
Number of lesions	309 (93.6)	11.00 (7.00–16.00)	
single	5 (1.5)	1.00 (1.00–1.00)	< 0.001*
multiple	304 (92.1)	11.00 (7.00–16.00)	
Lesion distribution			
peripheral	98 (29.7)	6.00 (3.00–9.00)	
central	2 (0.6)	3.50 (1.00-/)	< 0.001#
peripheral and central	209 (63.3)	14.00 (10.00–19.00)	
Side distribution			
unilateral	20 (6.1)	1.00 (1.00–3.00)	< 0.001*
bilateral	289 (87.6)	12.00 (8.00–16.50)	
Lung			
left	13 (3.9)	1.00 (1.00–3.00)	
right	7 (2.1)	1.00 (1.00–3.00)	< 0.001#
left and right	289 (87.6)	12.00 (8.00–16.50)	
Lung zone[1]			
left upper anterior	205 (62.1)	1.00 (0.00–1.00)	
left upper posterior	219 (66.6)	1.00 (0.00–1.00)	
left middle anterior	222 (67.3)	1.00 (0.00–1.00)	
left middle posterior	237 (71.8)	1.00 (1.00–2.00)	
left lower anterior	230 (69.7)	1.00 (0.00–1.00)	
left lower posterior	278 (84.2)	1.00 (1.00–2.00)	
right upper anterior	191 (57.9)	1.00 (0.00–1.00)	0.887#
right upper posterior	208 (63.0)	1.00 (0.00–1.00)	
right middle anterior	214 (64.8)	1.00 (0.00–1.00)	
right middle posterior	241 (73.0)	1.00 (1.00–2.00)	
right lower anterior	222 (67.3)	1.00 (0.00–1.00)	
right lower posterior	286 (86.7)	1.00 (1.00–2.00)	
Lung zone[1]			
upper	277 (83.9)	3.00 (1.50–5.00)	
middle	234 (70.9)	4.00 (2.00–6.00)	< 0.001#
lower	301 (91.2)	4.00 (3.00–6.00)	
Lung area[1]			
anterior	278 (84.2)	5.00 (3.00–7.00)	< 0.001*
posterior	307 (93.0)	6.00 (4.00–9.00)	
Lung[1]			
left	302 (97.7)	6.00 (3.00–8.00)	0.982*
right	296 (95.8)	5.00 (3.00–8.00)	

Results are expressed as number (%) or median (IQR- interquartile range: 25–75th percentile); [1]Cumulative percentage; *Mann-Whitney test; #Kruskal-Wallis test.

Fig. 3 – Axial thin-section unenhanced computed tomography (CT) scan shows bilateral ground-glass opacities (GGO) with reticulation, bronchiectasis and bronchovascular thickening with central and peripheral distribution.

Fig. 4 – Axial thin-section unenhanced computed tomography (CT) shows bilateral crazy paving pattern with vascular enlargement in the upper and lower left lobe and in the upper right lobe with central and peripheral distribution .

Fig. 5 – Axial thin-section unenhanced computed tomography (CT) scan shows right unilateral consolidation with air bronchogram with peripheral distribution in the right lower lobe.

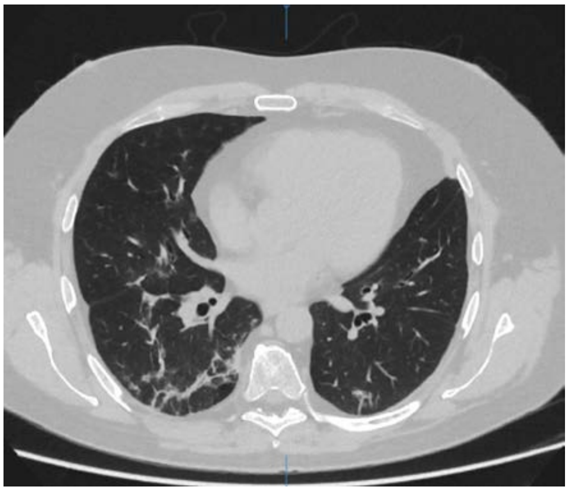

Fig. 6 – Axial thin-section unenhanced computed tomography (CT) scan shows left pleural thickening with bilateral subpleural lines and fibrous stripes in the posterior segments of the lower lobes.

Table 3

Computed tomography (CT) features in the patients with coronavirus disease 2019 (COVID-19) according to time of CT screening from onset of the disease

CT feature	All patients	Group 1 < 7 days	Group 2 7–14 days	Group 3 > 14 days	*p*-value*
Total number of patients	330 (100)	75 (22.7)	100 (30.3)	155 (47.0)	
CT positive findings	309 (93.6)	60 (80.0)	95 (95.0)	154 (99.4)	< 0.001
ground-glass opacities	302 (97.7)	58 (96.7)	92 (96.8)	152 (98.7)	0.522
reticular pattern	282 (91.3)	55 (91.7)	89 (93.7)	138 (89.6)	0.538
crazy paving pattern	65 (21.0)	22 (36.7)	28 (29.5)	15 (9.7)	< 0.001
consolidation	221 (71.5)	44 (73.3)	75 (78.9)	101 (66.2)	0.203
air bubble sign	21 (6.8)	7 (11.7)	7 (7.4)	7 (4.5)	0.171
vascular dilatation	147 (47.6)	39 (65.0)	48 (50.5)	60 (39.0)	0.002
fibrotic streaks	197 (63.8)	15 (25.0)	59 (62.1)	123 (79.9)	< 0.001
nodules	32 (10.4)	5 (8.3)	15 (15.8)	12 (7.8)	0.112
halo sign	71 (23.0)	15 (25.0)	31 (32.6)	25 (16.2)	0.011
reversed halo sign	29 (9.4)	4 (6.7)	11 (11.6)	14 (9.1)	0.584
subpleural line	76 (24.6)	2 (3.3)	19 (20.0)	55 (35.7)	< 0.001
subpleural transparent line	63 (20.4)	5 (8.3)	17 (17.9)	41 (26.6)	0.009
air bronchogram	49 (15.9)	10 (16.7)	18 (18.9)	21 (13.6)	0.528
bronchiectasis	194 (62.8)	39 (65.0)	66 (69.5)	89 (57.8)	0.166
thickening of the bronchial wall	195 (63.1)	40 (66.7)	66 (69.5)	89 (57.8)	0.146
pleural retraction	12 (3.9)	0	1 (1.1)	11 (7.1)	0.012
pleural effusion	29 (9.4)	5 (8.3)	10 (10.5)	14 (9.1)	0.887
pleural thickening	64 (20.7)	14 (23.3)	17 (17.9)	33 (21.4)	0.684
lymphadenopathy	9 (2.9)	0	3 (3.2)	6 (3.9)	0.307
Pericardial effusion	12 (3.9)	3 (5.0)	4 (4.2)	5 (3.2)	0.821

Results are expressed as number (%); *χ^2 test .

consolidation in 71.5%, fibrotic streaks in 63.8%, thickening of the bronchial wall in 63.1%, bronchiectasis in 62.8% and vascular dilatation in 47.6% (Table 3, Figures 3–6).

Discussion

In this study we examined the demographics, clinical characteristics and chest CT findings for 330 COVID-19 patients which were treated in our hospital with more detailed analysis of he most common findings.

Of the total number of patients, the majority (66.4%) were men, and the average age of patients was 52.37 ± 15.36, which is in accordance with previous studies [6, 15, 16].

As for symptoms, as in other available studies [15, 16], they were dominated by fever (86.4%), coughing and sputum (73.9%), fatigue (68.2%), muscle pain (54.8%), shortness of breath (38.8%), which correlates with the fact that the disease primarily affects the respiratory system. A significant number of patients (15.5%) also had digestive symptoms such as diarrhoea, abdominal pain and vomiting, as has been reported by other authors [15] and may confirm the hypothesis of an association between the gastrointestinal symptoms with the pathogenesis of the COVID-19 infection and the involvement of angiotensin-converting enzyme 2 receptor (ACE-2) which shows a high expression in the gastrointestinal tract as well.

The most common comorbidities in our patients were arterial hypertension (37.6%), obesity (29.7%), diabetes (9.7%), other lung diseases and chronic renal failure (both 6.7%), which, in some published papers have shown, correlate with the severity of the clinical features [17].

Considering the study included nine pregnant women, it is important to note that the CT scan is essential for evaluation of the clinical conditions in these patients and the risk benefit ratio of the diagnostic procedure is acceptable [18]. Radiation exposure through CT scan is at a dose much lower than the exposure associated with fetal harm [19]. According to the American College of Radiology and American College of Obstetricians and Gynecologists, when a pregnant woman undergoes a single chest CT scan, the radiation dose to the fetus is 0.01– 0.66 mGy [19].

As for laboratory findings, lymphopenia is considered by some authors [20] as a cardinal laboratory finding, with prognostic potential. A recent meta-analysis noted that 35–75% of COBID-19 patients developed lymphopenia [21], and that percentage in our study was 34.8%. An increased monocyte count was also found in a significant (67.99%) number of patients which also supports other studies published and whose authors go on to say that monocytes are primarily involved in triggering the hyperinflammatory immune response [22, 23]. Blood parameters, such as increased ferritin (70.9%), C-reactive protein (CRP) (63.0%), lactate dehydrogenase (LDH) (37.6%), erythrocyte sedimentation rate (35.5%) have also emerged as poor prognostic factors [20, 21], although ferritin is referred to as a key mediator of immune dysregulation [24].

As for CT findings, almost all patients included in the study (93.6%) had changes in their CT, with only 1.5% having a single lesion and 92.1% having multiple lesions, but it should be noted that a normal CT finding was found in a number of COVID-19 patients. Some studies [12, 15] correlated the extent of lesions with the time that elapsed from the onset of symptoms to the CT examination and found that in patients with less prevalence and single lesions, this time was significantly shorter and these patients underwent CT examination at a significantly earlier stage of the disease. In that sense, our study showed that in patients examined in the first week after the onset of symptoms (group 1), CT signs were found in 80.0% of patients, in group 2 in 95.0% of patients, and in group 3 in 99.4% of patients.

When it comes to the distribution of lesions, it can be observed that the majority were bilateral lesions (87.6%) and combined peripheral and centrally localized lesions (63.3%). These most often affected the posterior (93%) and lower zones (91.2%). These results also do not deviate from other studies, and can be partly explained by the anatomy of the tracheobronchial tree, which does not branch evenly and symmetrically and, especially in the earlier stages of the disease, may allow the virus to infect individual branches more frequently, leading to an uneven distribution [15, 25].

When we analyse an individual CT feature, GGO was the most common CT finding (97.7%), which correlates with the results of other studies [14, 26, 27]. By frequency, the reticular pattern results closely followed GGO (91.3%), and can be related to interstitial lymphocyte infiltration which leads to interlobular septal thickening [14, 27, 28]. There was no significant difference in any of the 3 groups of patients when GGO and reticular patterns occur (GGO: 96.7%–98.7% and reticular pattern: 89.6%–93.7%).

The crazy paving pattern which can be defined as a combined GGO and reticular pattern in the same location and as a result of alveolar oedema and interstitial inflammation of an acute lung injury did not occur as frequently (21%) as each of the components individually [13, 14]. However, unlike GGO and reticular pattern, crazy paving pattern showed a significant difference in time distribution, with this most evident in the group 1 (36.7%) and least often in the group 3 (9.7%), which is in line with the assumption that this indicates acute damaged lungs.

Consolidation, according to our study, is a common finding (71.5%) in patients with COVID-19, although some previous studies show a wide frequency range of 2– 64% [14]. Consolidation can be linked to cellular fibromyxoid exudates in alveoli [29], and can be considered a predictor of disease progression. Recent studies have shown that changes in the lungs progress to consolidation up to about two weeks after the onset of symptoms [13], and these findings are confirmed by our results which showed that consolidation was more common in the groups 1 and 2 (73.3% and 78.9%, respectively), compared to the group 3 (66.2%), but without a statistically significant difference among groups.

We observed vascular dilatation in 47.6% of the patients, with this occured significantly more often in the group 1 (65%) compared to the group 3 (39%), which could be attributed to thickening and damage of the walls of the blood vessels caused by proinflammatory factors [14] in the early phase of the disease, compared to the advanced phase.

Bronchial changes, primarily bronchiectasis and bronchial wall thickening were found in our study in 62.8% and 63.1% of the patients, with no significant difference in time distribution. This is in contrast to other authors who reported these manifestations in smaller percentage of cases, bronchiectasis up to 11% [12], and bronchial wall thickening up to 23% [26]. Regardless bronchial changes are the consequence of bronchial obstruction and inflammatory damage of the bronchial wall, with consequent fibrotic changes, Li et al. [26] showed a correlation of bronchial changes with the severity of the clinical picture in a sample of 83 COVID-19 patients.

Some changes occurred significantly more often in patients from the group 3, and here we primarily mean fibrotic streaks (79.9%), subpleural line (35.7%), subpleural transparent line (26.6%) and pleural retraction (7.1%). These changes are characteristic of the advanced phase of the disease and they may correspond to repair changes.

Conclusion

CT has proven to be a very important diagnostic method, and its ability to show the distribution, shape, degree of involvement, as well as typical radiological characteristics accurately, gives it a key role in diagnosing and monitoring patients with COVID-19 pneumonia. However, CT findings in COVID-19 patients have been shown to give a variety of patterns, most commonly involving lung and bronchial changes, which require a deep understanding by radiologists, but further research, especially in terms of time distribution is necessary. Together with clinical and laboratory findings, CT gives a complete picture of the patient's condition and contributes significantly to decision-making on further treatment.

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