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Chest Imaging ORIGINAL ARTICLE

Radiological findings in 136 patients suspected of Coronavirus disease 2019 (COVID-19)

Christos Tsiamis, Athanasios Papathanasiou-Papaeuthimiou, Sofia Gioulvanivou
Department of Radiology, General Hospital of Thessaloniki "O Agios Dimitrios", Greece

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ABSTRACT

Purpose: To describe and study the chest computed tomography (CT) and x-ray (CXR) radiological findings in 136 patients with clinical suspicion for COVID-19 infection.
Material and Methods: A total number of 136 patients, 84 males and 52 females, aged 21 to 90 years old, who came to the emergency department of our hospital complaining of symptoms similar to Coronavirus disease (COVID-19). After clinical examination and evaluation all these patients underwent PCR Test for COVID-19 and some basic blood tests as well. Since their clinical picture made them suspects for COVID-19 the next step included CXR and CT. The evaluation of CXRs and CTs was performed by three radiologists, without a specific scoring system, in consensus mainly for ground glass opacity (GGO), consolidation, location, lymphadenopathy, pleural effusion and pleural thickening.
Results: 66/136 (48.5%) patients were positive to COVID-19, while 70 had negative PCR Test. 52/66 (78.8%) positive patients were over 51 years old (up to 90 years). Radiological findings on chest CT in the 66 positive patients included GGOs (60 cases, 90.9%), while in 6 cases (9.1%) there were no abnormal findings. In most cases (52, 78.8%) the opacities were bilateral and in only 14 cases (21.2%) they were unilateral. GGOs were found mainly in middle and peripheral pulmonary zones, as well as middle and lower lung lobes. Besides GGO, imaging findings commonly included lymphadenopathy (34, 51.5%), pleural effusion and thickening (18, 27.3%). Less frequent findings included crazy paving (10, 15.1 %), septal thickening and lines (7, 10.6 %), air-space consolidation (5, 7.5 %) and reticular pattern (9, 13,6 %). 44/66 (66.7%) positive patients showed abnormal findings on CXR, while 22 (33.3%) had normal CXR. Chest CT in 14/70 (20.0%) negative patients demonstrated lung consolidation and GGO. 54/70 of the negative patients (77.1%) had normal chest x-rays.
Conclusions: The majority of patients with positive PCR Test had abnormal findings on CXRs and CT. Abnormal CT findings were mainly bilateral, multi-focal GGO. Abnormal findings in patients with COVID-19 were related to their age, in particular these were milder in younger patients.

CORRESPONDING AUTHOR, GUARANTOR

Athanasios Papathanasiou-Papaeuthimiou
Department of Radiology, General Hospital of Thessaloniki "O Agios Dimitrios", 2 Elenis Zografou Str., 54634 Thessaloniki, Greece Email: thanospap53@outlook.com

KEY WORDS
COVID-19; Chest Computed Tomography; Chest Radiographs; Ground Glass Opacities

Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by coronavirus 2 (SARS-CoV-2). It was officially recognised as a pandemic by the World Health Organisation (WHO).

In our hospital we treated many patients with COVID-19 infection, from the very beginning of the pandemic in Greece. The aim of the study was to describe the chest computed tomography (CT) and chest x-ray (CXR) radiological findings in 136 patients with clinical suspicion for COVID-19 infection.

Clinical presentation: People with COVID-19 have had a wide range of reported symptoms, ranging from mild symptoms to severe illness. Symptoms may appear 2-14 days after exposure to the virus. A significant percentage of patients infected with SARS-CoV-2 remain asymptomatic throughout the course of their illness, acting as carriers. Typical clinical presentation of COVID-19 involves mainly systemic and /or respiratory manifestations. The most common symptoms and signs are non-specific and include: fever (85-90%) , cough (65-70%), anosmia (and other taste or smell disturbances) (40-50%) , fatigue (35-40%), sputum production (30-35%) and breath shortness (15-20%). Less common manifestations include : myalgia/arthralgia (10-15%), headaches (10-36%), sore throat (10-15%), chills (10-12%), pleuritic pain and diarrhoea (3-34%), while rare manifestations can be nausea, vomiting, abdominal pain, GI bleeding , nasal congestion (<10%), palpitations, chest tightness , haemoptysis, confusion, seizures, paraesthesia, altered consciousness, even stroke [1-3].

Complications of COVID-19 include: acute respiratory distress syndrome (ARDS), pulmonary embolism , deep vein thrombosis (DVT), myocardial ischaemia, cardiac arrest, myocarditis, delirium, viral encephalitis, diffuse leukoencephalopathy, coagulopathy, disseminated intravascular coagulation (DIC) , multiorgan failure [1-3].

Transmission

The virus is considered to be transmitted from human to human. It was initially thought to be transmitted in a similar way to the common flu, via contact with droplets of infected patients, upper respiratory tract secretions (e.g. from sneezing or coughing). Nowadays, aerosol and fomite (contaminated surfaces) transmission also occur.

Diagnosis

For definitive diagnosis of COVID-19 a positive PCR test is required. Other laboratory findings include: lymphopenia, thrombocytosis, increased prothrombin time (PT), increased lactate dehydrogenase, as well as elevated inflammatory markers (CRP and ESR), elevated D-dimer and elevated serum amylase.

Chest CT is not used to diagnose COVID-19, but is very helpful in assessing its complications, such as pneumonia. Patients requiring CT should undergo a non-contrast chest CT (unless iodinated contrast medium is indicated). Although less sensitive than chest CT, CXR is typically the first-line imaging modality used for patients with suspected COVID-19.

Radiological findings

The primary findings of COVID-19 on CXR and CT are those of atypical pneumonia or organised pneumonia.

Treatment and prognosis: Various treatment schemes and vaccines are currently (June 2021) available, although steroids such as dexamethasone seem to improve the outcomes in ventilated or oxygen–dependent patients.

Material and Methods

This retrospective study took place during the first phase of the COVID-19 pandemic in Greece (from 15 August to 14 November 2020), including patients who presented exclusively to the Emergency Department of one state hospital, complaining of symptoms suggesting COVID-19. A total number of 136 patients (84 males, 52 females) were included, aged from 21 to 90 years old. A specific protocol was followed in the initial phase, according to which all patients included in the study should have a PCR-Test for COVID-19, basic blood tests and CXR. Patients were then admitted to the hospital and underwent chest CT.

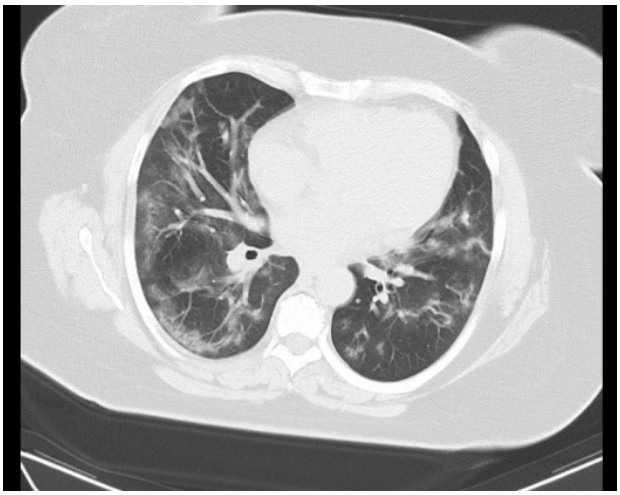

Fig. 1. *Chest HRCT axial image demonstrating bilateral ground glass opacities.*

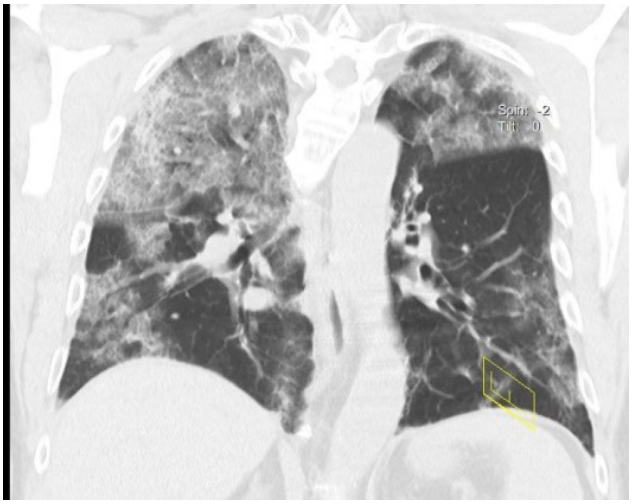

Fig. 2. *Chest HRCT coronal image demonstrating extensive ground glass opacities.*

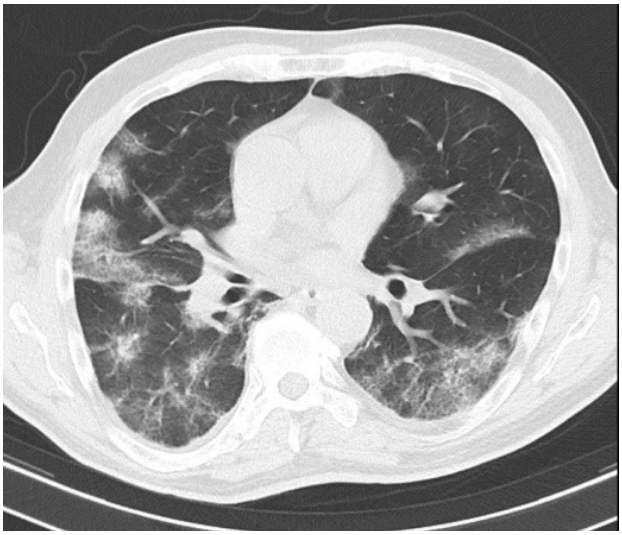

Fig. 3. *Chest HRCT axial image demonstrating bilateral GGOs.*

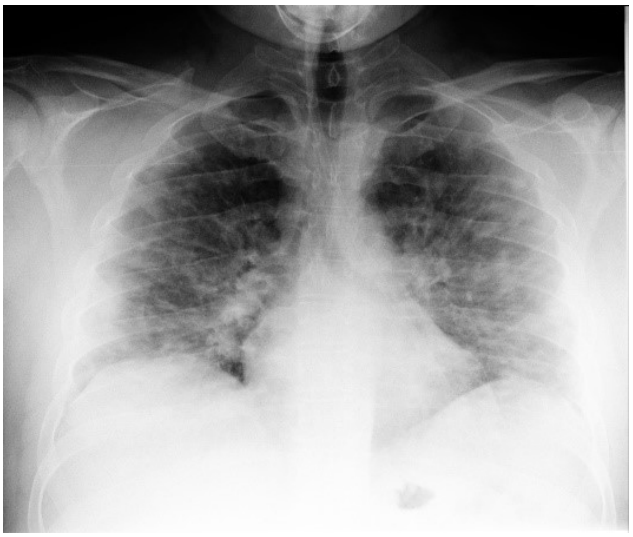

Fig. 4. *Chest CXR with peripheral, bilateral consolidations.*

Interpretation, analysis and assessment of imaging findings were performed by three radiologists (T.C , P.A and G.S). Images were digitally stored and analysed. No specific scoring system was used. Diagnosis was oriented in detecting GGO, consolidation, lymphadenopathy, pleural effusion and pleural thickening. Other less common findings included crazy paving, air-space consolidation, septal thickening and lines and reticular pattern. Upon disagreement, conclusion was set after discussion and mutual consensus.

Plain radiograph

Posteroanterior and lateral standing views were obtained, oriented in the detection of primary findings of COVID-19 on CXR, pneumonia and lung consolidation.

CT scan protocol

Non-contrast chest CT scanning was performed on a MDCT Siemens 16-detector scanner. When contrast-enhanced scanning was added (e.g. in CT pulmonary angiograms to exclude pulmonary thromboembolism), a non-contrast scan was always included prior to contrast administration, as contrast may impact the interpretation of GGO patterns, in accordance with most relevant international studies [4-7]. Patients were placed in the supine position and sliced ranged from the level of the

Table 1. Age groups of our study in relation to the sex of the patients

	Group A (<30 years)	Group B (31-40 years)	Group C (41-50 years)	Group D (51-60 years)	Group E (61-70 years)	Group F (>70 years)
Females	2	1	4	6	8	31
Males	0	5	16	17	18	28
Total	2	6	20	23	26	59

Table 2. Number of patients in relation to the PCR Test results

	Group A (<30 years)	Group B (31-40 years)	Group C (41-50 years)	Group D (51-60 years)	Group E (61-70 years)	Group F (>70 years)
Positive PCR Test	2	2	8	16	16	22
Negative PCR Test	0	4	12	7	10	37
Total number of patients	2	6	20	23	26	59

Table 3. Chest CT findings in the 136 patients of our study.

	GGOs	Lymphadenopathy	Pleural effusion or thickening	Normal CT
Positive PCR Test (66 pts)	60	34	18	6
Negative PCR Test (70 pts)	14	17	9	56
Total findings	74	51	27	62

Table 4. CXR findings in the 136 patients of the study

	Normal CXR	Abnormal findings (lung infiltrates) on CXR
Positive PCR Test (66 patients)	22	44
Negative PCR Test (70 patients)	54	16

upper thoracic inlet to the inferior level of the costophrenic angle. The following parameters were used: detector collimation width 16 X 1.2 mm, tube voltage 120 KV. Images were reconstructed with a slice thickness of 1.5 mm and an interval of 1 mm. Reconstructed images were sent to a dedicated workstation and picture archiving system (Siemens Somatom Perspective – Syngo Acquisition Workplace).

Results

Patients were divided in six groups according to their age **(Table 1)** and PCR Test **(Table 2)**. PCR Test results were positive in 66/136 patients and negative in 70. Of the 66 positive patients, 52 were aged 51-90 years old. Since the study took place during the first phase of the pandemic, most patients who were positive to COVID-19 were in the very first stages of the disease and thus small variety and low frequency of findings were found. From the 66 confirmed patients only six had normal chest CT scans. In 60 patients CT demonstrated GGO (90.9), bilateral (46 patients) or unilateral (14 cases), in 34 lymphadenopathy (51.5%) and in 18 (27.3%) pleural effusion or thickening **(Table 3)**.

GGO lesions were usually rounded or ill-defined, located mainly in the middle and peripheral pulmonary

Table 5. Radiological findings in the 66 positive patients in relation to age.

Age Group	CXR		Chest CT Findings				
	Normal	Abnormal	Normal	Ground Glass Opacities		Pleural effusion or thickening	Lymphadenopathy
				Unilateral	Bilateral		
<30 years	2	0	0	0	2	0	0
31-40 years	0	2	0	0	2	0	2
41-50 years	2	6	0	2	6	3	5
51-60 years	6	10	2	6	8	2	6
61-70 years	4	12	2	2	12	5	8
>70 years	8	14	2	4	16	8	13

Table 6. Radiological findings in the 70 negative patients in relation to age

Age Group	CXR		Chest CT Findings				
	Normal	Abnormal	Normal	GGOs		Pleural effusion or thickening	Lymphadenopathy
				Unilateral	Bilateral		
<30 years	1	0	0	0	0	0	0
31-40 years	3	0	3	0	0	0	0
41-50 years	8	4	6	4	2	0	2
51-60 years	4	2	5	2	0	1	1
61-70 years	6	4	6	2	2	2	3
>70 years	32	6	36	2	0	6	11

zones, as well as in the middle and lower lung lobes. Mediastinal lymphadenopathy was also a common finding in positive patients, with the size and number of affected lymph nodes increasing with patient age. Pleural effusions were usually of moderate size and unilateral. Bilateral and larger pleural effusions were more common in patients with more severe disease.

Normal CXR was found in 22/66 positive patients (33.3%) and 54/70 negative patients (77.1%). Abnormal findings (lung consolidation) on CXRs were found in 44/66 positive patients (66.7%) and in 16/70 negative patients (22.9%) **(Table 4)**.

Depending on patient age, in small ages (up to 40 years) 4/8 (50%) patients showed bilateral GGO, 2/8 (25%) lymphadenopathy and 2/8 (25%) had normal CXR. In middle ages (41-60 years old) almost all cases (22/24, 91.7%) showed GGOs (8 unilateral-14 bilateral, **Figs. 1-4**). In 5/24 (20.8%) cases chest CT demonstrated pleural effusion or pleural thickening and in 11/24 (45.8%) lymphadenopathy. In older patients (61-90 years old) the majority (34/38, 89.5%) presented GGO (mostly bilateral), 13/38 (34.2%) pleural effusion or thickening and 21/38 (55.3%) lymphadenopathy **(Table 5)**.

Less frequent findings included crazy paving (15.1 %),

air-space consolidation (7.5 %), septal thickening and lines (10.6 %) and reticular pattern (13.6 %). From the 70 negative patients 56 had normal CT scans (80 %) and 14 (20 %) abnormal CT scans **(Table 3)**.

In negative patients, 56/70 (80.0%) had normal CT scan findings, 54/70 (77.1%) had normal CXR, while only 14/70 (20.0%) of the negative patients presented abnormal CT findings **(Table 6)**.

Discussion

People with COVID-19 have presented with a wide range of symptoms, ranging from mild symptoms to severe illness. Symptoms may appear 2-14 days after exposure to the virus. Some of the patients remain asymptomatic throughout the course of their illness, acting as carriers. The most common symptoms and signs are non-specific and include fever, cough, anosmia, fatigue and breath shortness. In our case the 136 patients presented with the typical clinical manifestations for COVID-19 [1-3].

For definitive diagnosis of COVID-19 a positive PCR test is required. Chest CT is very helpful in assessing complications, such as pneumonia. Although less sensitive than chest CT, CXR is typically the first-line imaging modality. The commonest findings in both modalities are those of pneumonia.

PCR remains the only specific method of diagnosis, even if imaging is normal: a normal chest CT does not effectively exclude COVID-19 and an abnormal CT is not specific for COVID-19. Nevertheless, radiologists should be familiar with the imaging findings of COVID-19 in order to set a diagnosis, to differentiate from other causes of acute lung injury and to identify complications such as pulmonary embolism, empyema, or co-infection. Various studies mainly in China demonstrated that up to 30 % of patients with negative PCR examination had positive CT findings [7-9]. In our study 20% of patients with negative PCR Test had abnormal CT scans, compared to 91% of patients with positive PCR Test.

Normal Chest CT was found in 9% of confirmed patients. The relation between PCR Tests results and Chest CT findings were in general concordant to international literature [7-9]: bilateral, multifocal GGOs located peripherally, mainly in the lower lobes. Less common findings were lymphadenopathy, septal thickening and pleural effusion or thickening. International studies have shown similar frequency of GGOs in positive patients younger than 50 years (up to 75%) with our study (67%). However, in positive patients over 50 years old, GGOs were reported in up to 55% of patients, lower than the frequency observed in our study (89%), where increasing rate was found with age [6, 8, 10-12], while fewer lesions were seen in younger patients. No significant differences were observed according to sex.

Findings on CXR were consistent with previously published studies: our study found abnormal findings in 67% of positive patients, comparable to 59% observed in similar studies. Consolidation was the most common finding, with peripheral distribution and bilateral involvement found in up to 50%. Pleural effusions were uncommon (less than 5%). Positive patients in our study with abnormal CXR findings were 67%, similar to studies in the literature [7, 9, 10, 12].

Altogether, our results suggest that CXR can have a role in the initial screening for COVID-19. Although further studies are needed, upon high clinical suspicion of COVID-19 it is conceivable that an abnormal CXR may obviate the need for a CT examination. In our study, all confirmed positive patients who underwent both CXR and CT, had abnormal CXRs and CT scans. This result is consistent with relevant studies in the literature [7, 9, 10, 12].

Conclusions

The majority of patients with positive PCR Test had abnormal findings on CXRs and CT scans. Imaging findings in positive patients are related to their age, being milder in younger patients. Abnormal CXRs findings in positive COVID-19 patients more frequently present bilateral consolidation in the lower zones of the lungs. Chest CT findings mainly include bilateral, multi-focal GGOs, usually with ill-defined margins and predominance in the periphery of middle and lower lobes. In late stages of the disease or in more severe cases, the lesions can evolve into a diffuse GGO predominance or consolidation pattern. **R**

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Ethical approved

"The Institutional Review Board of Agios Dimitrios Hospital waived patient consent form due to the retrospective nature of the study"

Conflict of interest

The authors declared no conflicts of interest.

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