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Lung cavitation as a consequence of coronavirus-19 pneumonia

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Abstract. – OBJECTIVE: There are reports confirming that the development of pulmonary cavities is an atypical CT finding in patients after COVID-19 pneumonia. Before the SARS-Cov-2 pandemic, we knew that the most common causes of pulmonary cavities were mycobacterial, fungal or parasitic infections. Rapidly increasing incidence of pneumonia in the course of COVID-19, and thus, tomographic examinations of the lungs proved that one of the rare complications of this disease may also be cavity development. The aim of the study was to assess the incidence of pulmonary cavities in patients after SARS-CoV-2 pneumonia. We also aimed to analyze the changes accompanying the pulmonary cavities in our patients.

PATIENTS AND METHODS: We performed a retrospective analysis of 206 lung CT scans of patients with SARS-CoV-2 infection. In 28 of them, prior radiological examination revealed the presence of pulmonary lesions – these patients were disqualified for the study.

RESULTS: Out of 178 enrolled patients, 6 developed pulmonary cavities (3.37% of all cases). The most frequent changes coexisting with cavitary lesions in our material were: ground glass opacities, reticular pattern, bronchiolectasis and subpleural bands.

CONCLUSIONS: Our study confirms the similar incidence of pulmonary cavities after COVID-19 than previously reported. It also incites the clinicians to pay attention to the possibility of the occurrence of this complication.

Key Words:
COVID-19, SARS-CoV2, Pulmonary cavitation, Pneumonia, Computed tomography.

Introduction

Due to the large number of coronavirus disease 19 (COVID-19) cases around the world, the availability of radiological material assessing changes in the lungs is becoming more and more extensive. Chest computed tomography (CT) has become a screening test performed in most patients suspected of SARS-CoV2 infection, often awaiting results of swab tests confirming the infection. A model of typical lung changes observed in computed tomography was developed fairly quickly.

Zheng's meta-analysis[1] shows that ground glass opacities (GGOs), vascular enlargement, interlobular septal thickening, and subpleural bands were the most common findings in all patients, but in those critically ill severe traction bronchiectasis, interlobular septal thickening, consolidations, crazy-paving pattern, reticulation, pleural effusion and lymphadenopathy were the most common. Other less typical CT findings include bronchiolectasis, bronchial wall thickening, reversed halo, atoll signs and air bubble signs, as described by Ye et al[2]. However, there are also patients who develop the atypical lesions, such as pulmonary cavities.

Cavity formation is most often associated with mycobacteria, fungal or parasitic infections[3]. It can also have the autoimmune or neoplastic origin. Recently, lung cavitation turned out to be a rare consequence of COVID-19 associated pneumonia. The frequency of lung cavitation in the course of COVID-19 remains unclear. The current literature consists primarily of single case reports[4-8], although a few retrospective analyses of radiological examinations of patients with COVID-19 suggest that lung cavities formation occurs in 1.7 to 11% of patients[2,9]. In Zamout et al[10], the incidence of cavities was estimated at 1.7% among all patients treated for COVID-19 in hospital, 3.3% among patients who developed COVID-19 pneumonia, and as much as 11% in patients admitted to the intensive care unit (ICU).

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The aim of our retrospective study was to assess the frequency of lung cavities as a consequence of SARS-CoV2 infection and pneumonia, based on CT images obtained from convalescent patients between 01.11.2020 and 31.03.2021. We also wanted to assess what kind of radiological changes coexisted with pulmonary cavities in our patients.

Patients and Methods

This retrospective analysis was based on clinical and radiological material collected in two separate medical institutions in Lublin, Poland: 2nd Department of Radiology and Department of Pneumonology, Oncology and Allergology. Inclusion criteria were limited to a diagnosis of COVID-19 in patients presenting to hospital between 01.11.2020 and 31.03.2021. We did not take into account patients in whom earlier available radiological examinations or other medical records showed the presence of pulmonary cavities or any history of pulmonary disease. Details were obtained from the medical records including demographics, past medical history, radiological findings, computed tomography (CT). Altogether, in the observation period of 5 months in our centers, we analyzed CT images of 206 patients admitted with the history of COVID-19 pneumonia at different stages, among whom 178 had neither history of previous pulmonary conditions nor, in particular, lung cavitation, and only those could be enrolled into the study.

According to the national regulations, our study did not require the Local Ethics Committee approval as a retrospective analysis of existing patients' medical records. Written informed consent for the computed tomography examination of the lungs was obtained from all patients.

Results

In total of 178 analyzed radiological records of patients with SARS-CoV2 infection and pneumonia, 6 patients developed lung cavitation which accounts for 3.37% of the entire group.

The clinical characteristics of patients with lung cavities are presented in Table I.

Patients 1 and 2 were diagnosed with severe form of COVID-19 pneumonia and needed prompt hospitalization in intensive care unit (ICU). They underwent intensive treatment according to the current recommendations of the Polish Association of Epidemiologists and Infectiologists[11] with intubation and mechanical ventilation. Relatively young, those patients were overweight and had concomitant diseases. The CT scans showed multiple diffuse changes with high CT scores (Figure 1 and 2).

Older patients, 3 and 4, with some concomitant diseases needed hospitalization in the course of COVID-19. They received the optimal treatment for infection, and because of the partial respiratory failure, they needed the oxygen supplementation. Their control CT scans in the convalescent period showed more advanced pulmonary changes and persistent high CT scores (Figure 3 and 4).

The other two patients – 5 and 6 – had mild form of COVID-19 pneumonia. They were hospitalized but they did not develop respiratory failure. They had a CT scan performed in the recovery period in order to establish the possible complications. Apart from big cavities, their CT images showed small remnant GGOs and reticular pattern, fibrosis, subpleural bands and singular air bubble changes (Figure 5 and 6).

All these six patients survived the infection and did not develop pulmonary embolism.

Discussion

The typical imaging signs of COVID-19 infection include GGOs, consolidations, crazy-paving pattern, reticular pattern, vascular enlargement, fibrosis, septa and air bronchogram predominant peripherally and in lower lobes. Less common changes include atoll and halo signs, airway changes, bronchiolectasis, bronchial wall thickening and traction bronchiectasis, nodules, lymphadenopathy or pleural changes[1-3,12].

Cavitary lung lesions are rare and usually late complications of COVID-19 infection appearing at different rate ranging from 1.7 to 11% in multiple studies[1,2,12]. In non-COVID-19 patients they are found after pulmonary embolism or infarction[3,13]. Otherwise, lung cavities are common after mycobacterial, parasitic, fungal infections or neoplasmatic diseases. In our patients none of this was confirmed. The pulmonary embolism or infarction was also excluded by imaging or clinical and laboratory tests. Furthermore, none of these patients had previous record or history

Table I. Characteristics of the study group.

Variable	Number of all patients = 206 Number of patients without any previous radiological changes and no previous lung disease in anamnesis = 178 Number of patients with lung cavities = 6
Male/Female	4/2
Mean age (from-to in years)	53.66 (35-70)
Cavities Side affected Both/Left/Right	5/1/0
Non-smoker/Smoker	3/3
Concomitant diseases	
Overweight	2
Obesity	1
Hypertension	2
Dyslipidemia	1
Hospitalization	6
Hospitalization in Intensive Care Unit Yes/No	2/4
Radiological changes coexisting with cavities:	
Reticular pattern	6
GGOs	5
Mucus filling /air bubble sign	4
Subpleural bands	4
Consolidations	3
Crazy paving	2
Bronchial wall thickening	2
Halo and atol signs	1
Pleural effusion	1
Pleural thickening	1
Bronchiectases	1
Vascular enlargement	1
Fibrosis	1
CT score mean (from – to):	13.3 (25-3)
Patient 1	20
Patient 2	25
Patient 3	14
Patient 4	13
Patient 5	3
Patient 6	5
Mean time from PCR diagnosis to CT showing cavities in days (from – to)	31.6 (15-48)
Patient 1	15
Patient 2	29
Patient 3	48
Patient 4	15
Patient 5	40
Patient 6	42

of pulmonary disease. The lung cavities were therefore attributed to the recent COVID-19 infection.

In our patients the most often changes co-existing with cavitary lesions were: ground glass opacities, reticular pattern, bronchiolectasis and subpleural bands.

GGOs are described as diffuse, hazy areas of little increased density on CT images, preserving normal bronchial and vascular pattern. They might be a consequence of partial filling of airspaces together with interstitial thickening and are typically seen bilaterally with peripheral and subpleural distribution in COVID-19 patients[14,15].

Reticular pattern corresponds to a thickened pulmonary interstitium involving interlobular septa and lines. This pattern is seen on CT images as multiple linear opacities and is thought to reflect the interstitial infiltration with lymphocytes. It is often present all along COVID-19 infection, accompanying GGOs and consolidations at earlier phases and as residual opacities in convalescent period[16,17].

Subpleural bands are thin curvilinear opacities lying less than 1 cm and parallel to the pleural

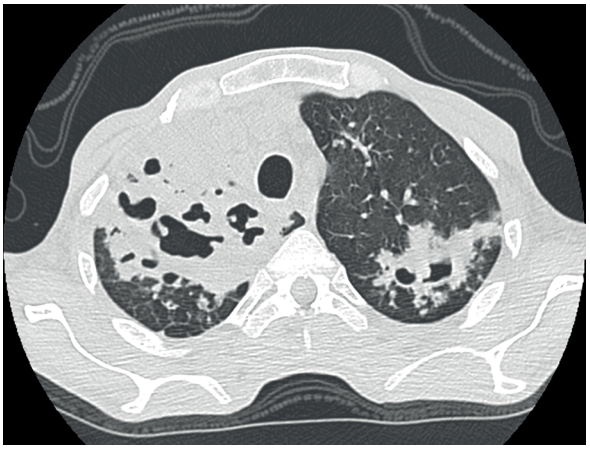

Figure 1. CT images of a 45-year old man with severe Covid-19 infection (day 15) and respiratory failure hospitalized at ICU. Multiple, big lung cavities mainly in the right upper lobe with diffuse big consolidations, patchy consolidations, peripheral GGOs with air bubble signs in the lower lobes. Reticular pattern can also be seen. Note no pleural effusion.

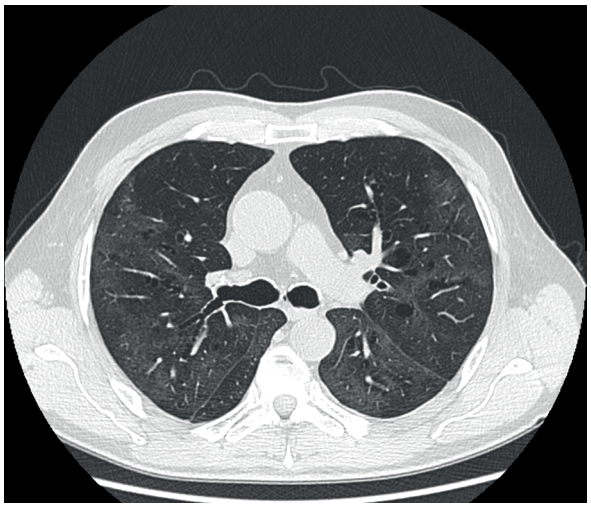

Figure 3. Axial HRCT images of a 70 y.o. convalescent man with mild Covid-19 infection, day 48. Control CT shows multiple, small and diffuse lung cavities in both lungs with persistent peripheral GGOs, reticular pattern and air bubble signs.

surface. They are thought to be linked with local pulmonary edema or reflect ongoing fibrosis bands later during COVID-19 infection. Some authors[18] claim their presence in up to 20% of COVID-19 patients.

Bronchiolectasis refers to a slight bronchiolar dilatation of distant, small bronchioles. In COVID-19 autopsy studies it was found to contain gelatinous mucus rather than air and be a cause of a dry, non-productive cough due to the high viscosity of the bronchioles contents[1,2]. A cross-section of bronchiolectasis obtained on CT images produces small low-density spaces in the lung, which is called air bubble sign. This air bubble sign has been reported as a typical COVID-19 imaging feature, appearing in 21 to 80% of patients depending on the study. Air bubble sign has been also attributed to the partial resorption

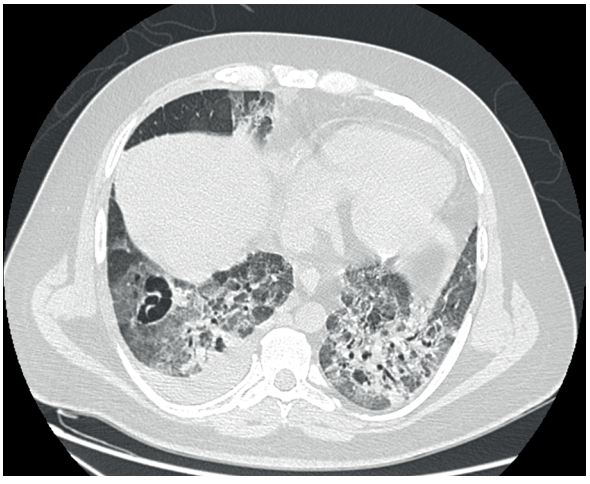

Figure 2. Multiple diffuse GGOs and consolidations with atol signs and crazy paving pattern in a 35 y.o. man hospitalized at ICU with respiratory failure – CT at day 29 after PCR diagnosis of Covid-19. Note the formation of lung cavities in the right lower lobe with numerous air bubble signs on the left side.

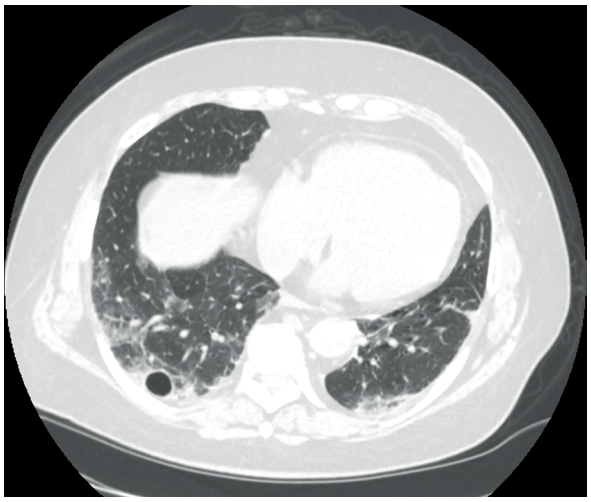

Figure 4. HRCT images of a 63 y.o. old woman at day 15 of Covid-19 pneumonia. Note multiple diffuse consolidations with GGOs, reticular and crazy paving pattern, together with subpleural bands and small lung cavitations.

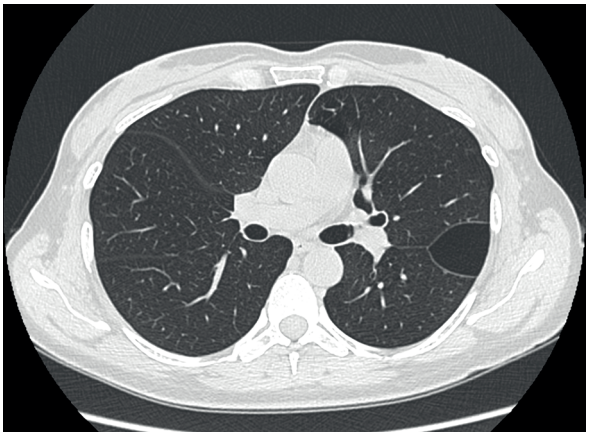

Figure 5. A control CT exam at day 40 after Covid-19 infection of a 57-y.o. woman shows a persistent, singular, interlobular lung cavity.

of consolidation[10,12]. Long-lasting mucous content in the small bronchioles, together with consolidations and inflammatory process in the lung parenchyma, may be responsible for inflammatory damage and progressive enlargement of the bronchioles, further leading to fibrosis, scaring or traction bronchiectasis and in the end lung cavities. This might explain why we have observed lung cavities also in patients with mild course of COVID-19 pneumonia, who did not need the aggressive treatment.

The incidence of lung cavitation rises with the severity of COVID-19 infection. Shi et al[9] shows cystic changes in 10% of COVID-19 patients and bronchiolectasis in 11%. Zoumot et al[10] reports 11% incidence rate of lung cavities in severe COVID-19 disease, in patients admitted to ICU, whereas 3.3% in patients with milder COVID-19 pneumonia and hypothesizes multifactorial reasons for lung cavitation. This would be consistent with our observations – six of our patients (3.37% of the total) with COVID-19 pneumonia developed the cavities. The progress into lung cavities might be linked with bacterial and fungal co-infections of ICU patients, barotrauma, the immunosuppressive drugs and potential of SARS-CoV2 infection to cause micro-infarcts leading later to cavitation. According also to Ozgül et al[19], cavitary lesions in the lungs in the course of COVID-19 may be associated with a bacterial infection, e.g., *Staphylococcus aureus*. Scharf et al[20] confirm that pro-thrombotic effects of SARS-CoV2 infection should be considered as another cause of damage to the pulmonary parenchyma in the course of pulmonary infarction, resulting from pulmonary embolism. It is well known that COVID-19 infection increases the risk of thrombotic complications. Marchiori et al[21] suggests that in the case of lung cavernous lesions in the course of COVID-19, alternative diagnoses should be sought. In fact, many patients do not have routinely performed CT scans of the lungs before SARS-CoV2 infection – in these patients we cannot conclude that the sole cause of cavity formation is COVID-19 pneumonia. However, there are some who have had radiological record before and in whom the cause-and-effect relationship with infection seems to be quite evident.

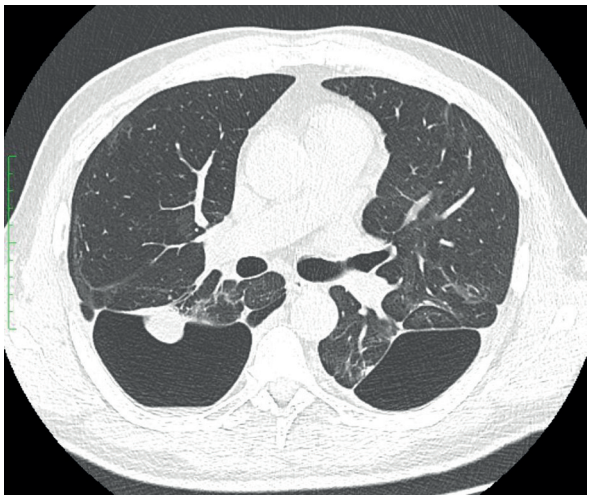

Figure 6. A control HRCT examination at day 42 after Covid-19 infection in a 52-y.o. man shows 2 big lung interlobular cavities in both lungs. Note persistent, diffuse GGOs and fibrotic bands with reticular pattern.

Conclusions

In conclusion, the clinical and imaging features, as well as late consequences of SARS-CoV-2 infection constantly evolve. Doctors must be aware that even in mild type of COVID-19, lung cavitation may appear and can be seen early after COVID-19 disease.

In our radiological material lung cavities were observed in 6 of 178 examined patients (3.37%). Ground glass opacities, reticular pattern, bronchiectasis and subpleural bands were the most often changes coexisting with cavitary lesions.

It is therefore important to appropriately follow-up the convalescent patients to exclude late

lung complications. The observation period of our patients is too short to anticipate the further evolution of changes and their impact on the survival period and quality of life of our patients.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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