REVIEW PAPER (PREGLEDNI RAD)

Radiological modalities in the detection, assessment and monitoring of COVID-19 infection

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Summary

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, posed a global health challenge that required rapid reorganization of healthcare systems and the implementation of strict protective measures. The gold standard for diagnosing COVID-19 is certainly the RT-PCR test, along with radiological methods that provide specific visual indications of the disease. The radiological presentation of COVID-19 includes chest radiographs used to evaluate lung changes, CT which offers a detailed view of abnormalities caused by the infection, PET/CT and LUS, which further assist in diagnosis and monitoring, and MRI used for a detailed assessment of complications and post-COVID syndrome. The complications of COVID-19 infection with the highest incidence are pulmonary, neurological, hematological, renal, and cardiac. During the pandemic, their severity and unpredictability became evident, as they further complicated the disease outcome and recovery. Post-COVID syndrome and MIS-C provide particular inspiration and motivation for new scientific research due to their characteristic clinical features.

Keywords: COVID-19; complications; infection; manifestations; radiology

Abbreviations and acronyms: ADEM (Acute Disseminated Encephalomyelitis), ARDS (Acute Respiratory Distress Syndrome), COVID-19 (Coronavirus Disease 2019), CT (Computed Tomography), FAST protocol (Focused, Fast Abbreviated Research Technique), GBS (Guillain-Barré Syndrome), GGO (Ground – Glass Opacity), LUS (Lung Ultrasound), MIS-C (Multisystem Inflammatory Syndrome in Children), MRI (Magnetic Resonance Imaging), PE (Pulmonary Embolism), PET (Positron Emission Tomography), RT-PCR (Reverse Transcription-Polymerase Chain Reaction), 18F-FDG (Fludeoxyglucose F18)

Introduction

The potential dangers of infectious diseases and the exhausting and demanding nature of fighting them, even in modern medicine, were clearly demonstrated during the SARS-CoV-2 pandemic. The history of this novel, previously unknown infectious disease, began in December 2019 in the city of Wuhan, China, when local authorities reported an increased number of cases of acute respiratory syndrome [1]. Given the high genomic similarity between the previously known SARS virus and the new coronavirus, the International Committee on Taxonomy of Viruses (ICTV) named the new virus SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2) [1]. Through human-to-human transmission, the virus unexpectedly spread rapidly to other continents, and the World Health Organization officially named the new infectious disease COVID-19 (Coronavirus Disease 2019). On March 11, 2020, the WHO declared the COVID-19 pandemic. The COVID-19 pandemic necessitated an urgent restructuring of healthcare systems worldwide, which faced numerous challenges and burdens, and the development of guidelines to combat the virus, with the aim of reducing the number of cases through responsible adherence to these guidelines.

Aim of the paper

The aim of this paper is to highlight the role and importance of radiology as a medical specialty in the diagnosis and treatment of COVID-19 infection. It also seeks to describe the specificities of the work of radiologic technologists with patients suffering from a previously unknown virus before 2019. Additionally, the paper aims to radiologically illustrate the most common manifestations and complications of COVID-19 disease.

Discussion

Radiological depiction of COVID-19 infection manifestations

The gold standard for diagnosing COVID-19 disease is the viral nucleic acid test, which is performed using reverse transcription polymerase chain reaction (RT-PCR). Alongside the PCR test, radiological methods are also used in the diagnosis of COVID-19, as they provide specific images that indicate the presence of disease.

Chest X-rays in the diagnostic imaging of COVID-19

The basic radiological diagnostic method for confirming and assessing COVID-19 disease is chest X-ray, with the most common abnormalities observed being consolidation and ground-glass opacity. Consolidation (Figure 1) refers to the occupation of air spaces, leading to the filling of alveolar spaces with pathological products such as water, pus, and blood in the lungs [2]. Ground-glass opacity (GGO, Figure 2) represents reduced lung parenchyma aeration while the vascular and bronchial markings remain preserved. GGOs are common in the early stages of infection and may potentially precede the appearance of consolidation [2].

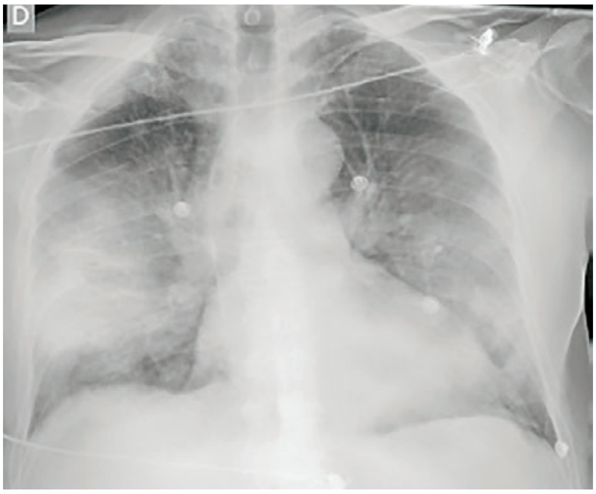


Figure 1. Bilateral ill-defined, patchy alveolar consolidation with peripheral distribution.
Source: https://pubmed.ncbi.nlm.nih.gov/34364071/

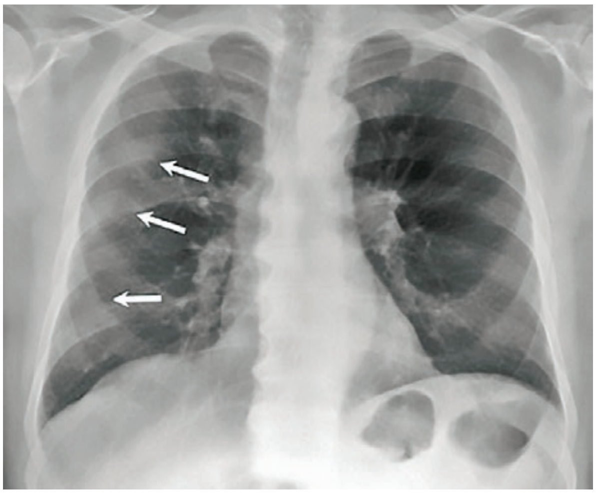


Figure 2. Patchy GGOs with peripheral distribution in the right lung.
Source: https://pubmed.ncbi.nlm.nih.gov/34364071/

Table 1. List of common radiological terms and their explanations used in computed tomography studies [4]

Term	Term explanation
ground-glass opacity - GGO	reduced transparency of lung parenchyma with preserved vascular and bronchial marks
„crazy paving“ opacity	thickening of intra and interlobular septa superimposed on GGO
consolidation	reduced pulmonary transparency which does not preserve vascular and bronchial marks
,,melting sugar sign“	GGO which increases on follow-up images, but decreased in attenuation, should not be interpreted as illness worsening
linear consolidation	thin consolidation situated parallel or perpendicular to pleura; seen in the late phase of organizing pneumonia
parenchymal bands	bands situated parallel or perpendicular to pleura; seen in the late phase of organizing pneumonia
perilobular opacification	opacification seen at the periphery of the secondary pulmonary lobule, may include interlobular septa, visceral pleura, lymphatics and vessels, often seen in any stadium of organizing pneumonia
reticulation	intra and inter-lobular septal thickening; mild form may be seen in the late phase of COVID-19 pneumonia
traction bronchiectasis	bronchal dilatation caused by surrounding fibrosis. The common findings in the late phase of COVID-19 pneumonia
honeycombing	indicative for the end-stage pulmonary fibrosis
bronchial distortion	A more appropriate term for description of the features of CO VID-19 pneumonia than traction bronchiectasis. In this case bronchial geometry is altered in some phase of the illness, but it does not necessarily mean irreversible changes. It may comprise temporary finding in the course of organizing pneumonia, with or without permanent sequelae. In the same way, it is recommended to use terms fissural distortion and blood vessel distortion before the confirmation of irreversible changes on follow-up MSCT scans in a longer time period.
fibrotic-like changes	Reticulation associated with bronchial dilatation and distortion in the areas of GGO and consolidation, may be present in the late phase of COVID-19 pneumonia. It comprises potential precursors of fibrosis, but with high probability of complete resolution in a longer time period (3-6 months or longer).
mosaic attenuation pattern	Abnormal hypodense areas consistent with the secondary pulmonary lobule which alternate with areas of normal parenchyma or GGO. It is described as a late feature of severe COVID-19 pneumonia. It is still unclear if it means residual illness of small airways or microvascular thrombosis.
organizing pneumonia	The pattern of organizing pneumonia on MSCT includes GGO, consolidation, reticulation, and parenchymal distortion.
post-COVID interstitial lung disease	residual pulmonary disease, usually 12 weeks after the onset of symptoms of COVED-19 pneumonia

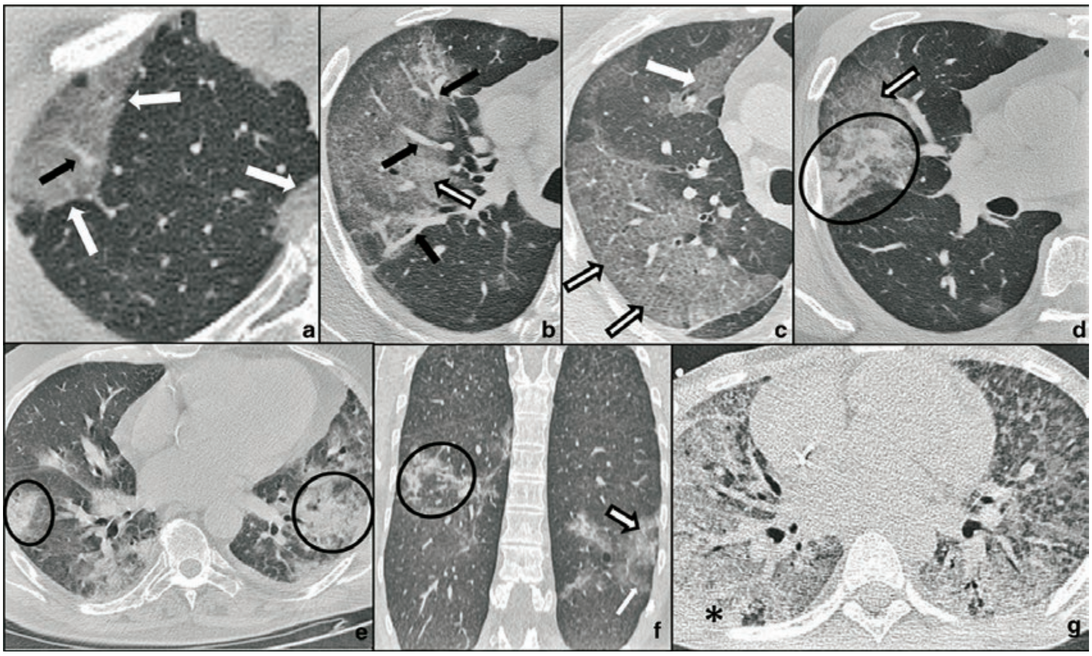


Figure 3. COVID-19 pneumonia phases: a) Stage 1; b,c,d) Stage 2; e) Stage 3; f) Stage 4; g) ARDS – representing a possible complication of COVID-19 pneumonia. Black arrows indicate the dilation of peripheral blood vessels, while white arrows indicate ground-glass opacities. The crazy paving pattern is shown with black-bordered white arrows. Black circles (d, e, f) represent dependent and non-dependent consolidations, while black asterisk in g denote dependent consolidations.
Source: https://doi.org/10.1186/s13244-021-00967-x

CT in the diagnostic imaging of COVID-19

The Fleischner Society has identified three main scenarios in which CT imaging can be the primary radiological diagnostic method: in patients with mild respiratory characteristics consistent with COVID-19 infection but with a significant risk of disease progression, or in patients with moderate to severe symptoms of infection, regardless of the PCR result, and in patients with moderate to severe symptoms in areas of high COVID-19 prevalence and reduced testing capacity [3]. Table 1 shows the most common radiological terms mentioned in MSCT examination reports [4].

Computed tomography has proven to be of exceptional importance in depicting and describing the four stages of COVID pneumonia:

- Stage 1 or early phase (0 – 4 days): opacities resembling “ground-glass” (Figure 3; a)
- Stage 2 or progressive phase (5 – 8 days): opacities with a crazy-paving pattern, GGO, and small consolidations (Figure 3; b, c, d)
- Stage 3 or peak phase (9 – 13 days): consolidations of the lung parenchyma, sometimes surrounded by a “halo” sign or GGO, followed by an atoll sign or reverse “halo” sign (Figure 3; e)
- Stage 4 or absorption phase (≥ 14 days): GGO and linear consolidations, which can be interpreted as a process of repair and reorganization [5] (Figure 3; f).

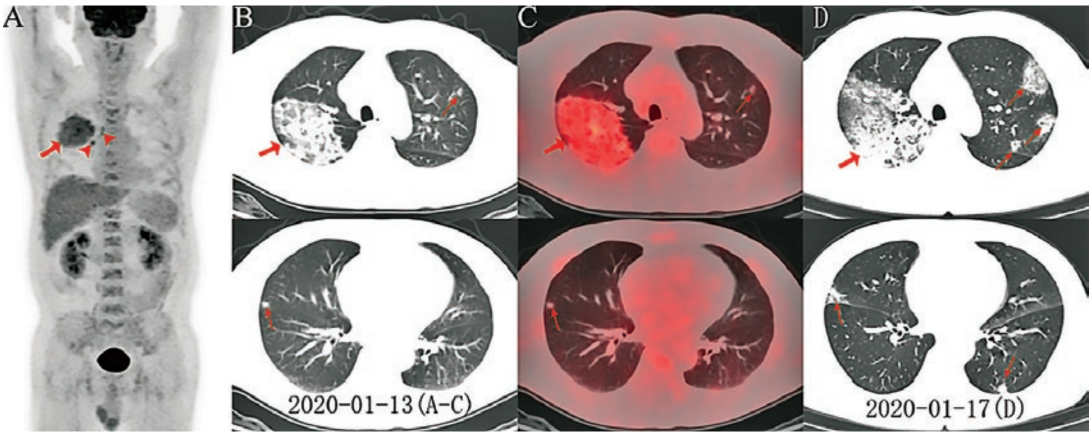


Figure 4. A) FDG PET/CT in a SARS-CoV-2 positive patient, B) Axial CT sections, C) PET/CT fusion showing opacities in the right upper and middle lobes and the left upper lobe, D) Follow-up CT scan showing progression of lesions.
Source: https://pubmed.ncbi.nlm.nih.gov/32142399/

PET/CT in the diagnostic imaging of COVID-19

Studies show that PET/CT is not routinely used in the diagnosis of COVID-19, particularly in emergency cases, but it certainly highlights a potential complementary role in the treatment of the disease. Since advanced disease can damage other organs, such as the kidneys, bone marrow, heart, and gastrointestinal tract 18F-FDG PET/CT can provide a non-invasive whole-body assessment to detect damage [6]. Zou and Zhu [7] observed radiopharmaceutical uptake in the right lung lobe, right hilar, and paratracheal lymph nodes (Figure 4). In the same study, they also discovered FDG accumulation in the bone marrow.

LUS in the diagnostic imaging of COVID-19

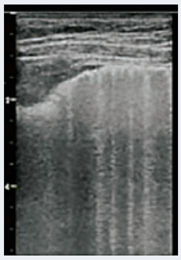
An alternative to standard diagnostic imaging for COVID-19 infection is another radiological method – lung ultrasound (LUS). LUS has proven to be particularly significant in children, pregnant women, and critically ill patients in intensive care units. An ultrasound image of healthy lungs shows the pleural line as a hyperechoic horizontal line (top of the green arrow in Figure 5;a) and multiple horizontal echoes of the pleural line, known as A-lines [8]. In severe interstitial pneumonia, the pleural line becomes irregular, and vertical echoes appear on LUS, indicating multiple blurred lines known as B-lines (Figure 5; b) [8].

One method for assessing lung involvement is a system that differentiates four stages of progressive loss of aeration. This system has shown high diagnostic value in patients with ARDS. Given this, it has been successfully applied to COVID-19 patients as well. The lungs are divided into 12 regions, each of which is examined via ultrasound, and the level of involvement is scored from 0 to 3. Examples of scores from 0 to 3 are shown in Table 2. The lung ultrasound result is then calculated by summing the scores for each region, with a higher total indicating reduced aeration [9].

MRI in the diagnostic imaging of COVID-19

MRI was not the first-choice method for imaging and confirming infection due to the duration of the examination and the challenges of implementing protective measures against potential transmission. However, it has proven to be highly important in imaging and monitoring complications of COVID-19 infection, post-COVID symptoms, and clinical research.

Table 2. LUS scores and representative ultrasound images [9]

Score	Aeration	Characteristics	Representative image
0	Normal	The pleural line is continuous and regular. Horizontal artefacts (A-lines), or two or fewer B-lines are present	
1	Moderate loss	The pleural line is indented. Below the indent, three or more well-spaced, non-confluent vertical artefacts (B-lines) are present	
2	Severe loss	The pleural line is broken. Below the breaking point, small-to-large consolidated areas (subpleural consolidations) appear, with associated areas of multiple confluent vertical artefacts (coalescent B-lines)	
3	Complete loss	The scanned area shows dense and largely extended white lung with tissue-like pattern (consolidation)	

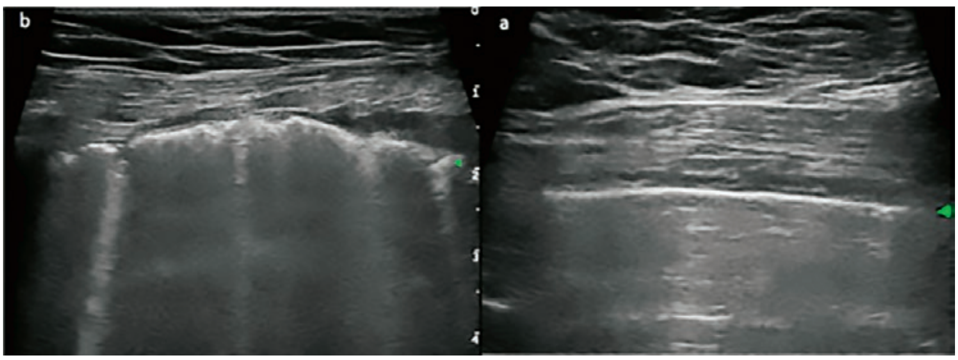


Figure 5. Ultrasound features of healthy lungs (a) and COVID-19 pneumonia (b).
Source: https://pmc.ncbi.nlm.nih.gov/articles/PMC7369598/

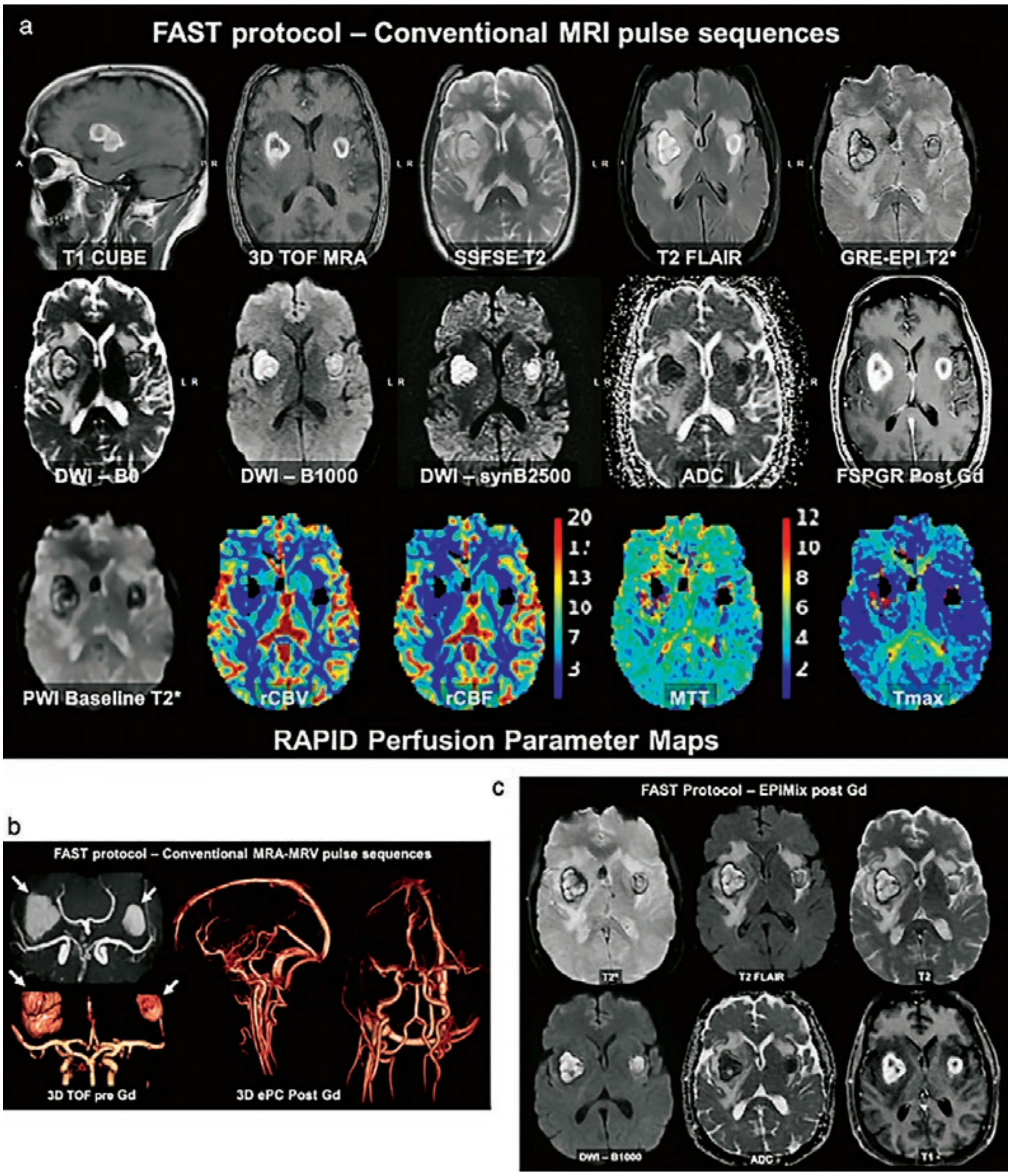


Figure 6. Focused, fast abbreviated survey technique (FAST) stroke protocol: a) By using parallel acceleration techniques, reduced matrices, compressed sensing, and other modifications, all images shown here required less than 15 minutes to acquire, and allowed complete characterization of lesions; b) 3D time-of-flight (TOF) MRA and 3D phase contrast MRA-MRV required 2 minutes, 10 seconds; c) using EPIMix, six high-quality tissue contrasts were acquired in just 75 seconds, with the procedure performed after gadolinium administration.
Source: https://onlinelibrary.wiley.com/doi/10.1002/jmri.28006

A challenge in successfully performing MRI exams was patients who were confirmed positive or suspected of being infected, as their symptoms, whether conscious or unconscious, interfered with the imaging process. It was particularly difficult to scan patients with dyspnea, frequent coughing, involuntary movements, or altered mental status in an MRI environment [10].

Whenever possible, radiologists and radiologic technologists considered the implementation of focused, rapid protocols during the pandemic to reduce the total scan time. An example of such a protocol in neuroradiology is shown in Figure 6. Using the FAST protocol (*Focused, Fast Abbreviated Research Technique*), subacute bilateral hemorrhages of the basal ganglia with surrounding vasogenic edema were observed, attributed to COVID-19 vasculopathy [10].

Most common complications of COVID-19 infection

Pulmonary complications

A well-known complication of COVID-19 infection is acute respiratory distress syndrome (ARDS). Figure 7 shows chest X-ray images of a 64-year-old male with COVID-19 ARDS, demonstrating the rapid progression of the disease [11].

The pathophysiology of ARDS involves damage to the alveolar epithelium, leading to increased permeability of the alveolar epithelial barrier, which causes the formation of a hyaline membrane, interstitial edema, and alveolar edema, resulting in severe hypoxia [12]. Therefore, patients with such complications are placed on non-invasive or invasive mechanical ventilation to improve oxygenation

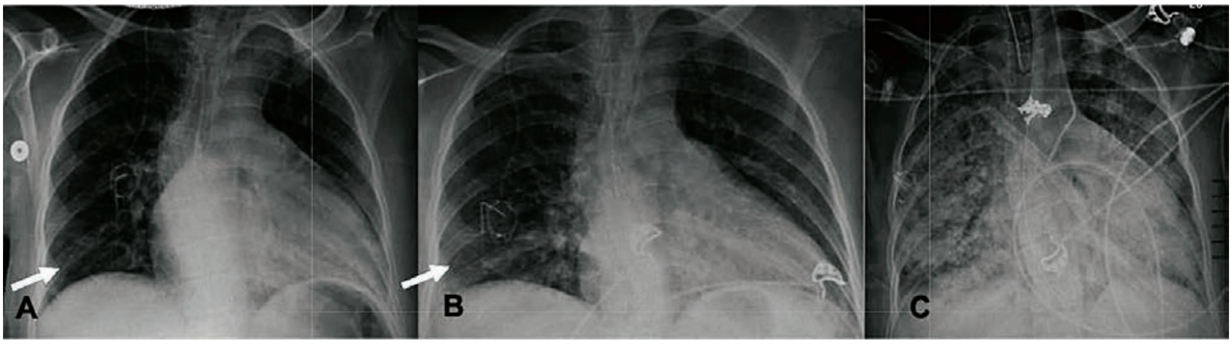


Figure 7. Serial frontal (AP) chest x-rays: A) initial chest x-ray with faint airspace opacities in the right lower lung, B) chest x-ray 2 days later shows increase in the airspace opacities, C) 4 days from the initial exam – rapid progression of bilateral airspace opacities.
Source: http://www.paom.pl/Pulmonary-complications-due-to-COVID-19-a-literature-review,136045,0,2.html

and maintain appropriate blood oxygen levels. Increased intra-alveolar pressure during mechanical ventilation can lead to alveolar rupture, resulting in barotrauma-related injuries such as pneumomediastinum and pneumothorax [12].

Neurological complications

Neurological damage due to COVID-19 infection can occur as a result of the direct effect of the virus or indirectly through the systemic response of the body to the infection [13]. The virus can cause damage to both the central and peripheral nervous systems, as well as muscle damage. The indirect systemic response to the infection is most commonly associated with a paraneoplastic autoimmune effect, known as the *"cytokine storm"*, which was observed in a significant number of patients in intensive care units during the COVID-19 pandemic. Clinical signs of the cytokine storm include elevated inflammatory markers (D-dimer, ferritin), fever, and increased pro-inflammatory cytokines (IL-6, TNF-alpha), which can lead to confusion and altered levels of consciousness [14].

Encephalitis is an inflammatory condition of the brain that has been described in many studies as a severe neurological complication of COVID-19 infection. Typical brain MRI findings in patients with encephalitis (Figure 8) showed diffuse hyperintensity in the white matter of the brain and hemorrhagic lesions on fluid-attenuated inversion recovery (FLAIR) and T2 sequences [15].

Acute Disseminated Encephalomyelitis (ADEM) represents an autoimmune inflammatory disorder of the central nervous system characterized by demyelinating lesions in the white matter of the brain and spinal cord [16]. In most cases, it occurs following an infection or vaccination, which is why it is referred to as post-infectious or post-vaccinal encephalomyelitis. The criteria for diagnosis are based on cerebrospinal fluid analysis and imaging findings from brain and spinal cord MRI (Figure 9).

Guillain-Barré Syndrome (GBS) is an autoimmune peripheral neuropathy whose main symptom is muscle weakness, ranging from slightly impaired gait to complete paralysis of all limbs, facial, bulbar, and respiratory musculature. Symptoms typically begin in the lower extremities and progress upward. Data from the international

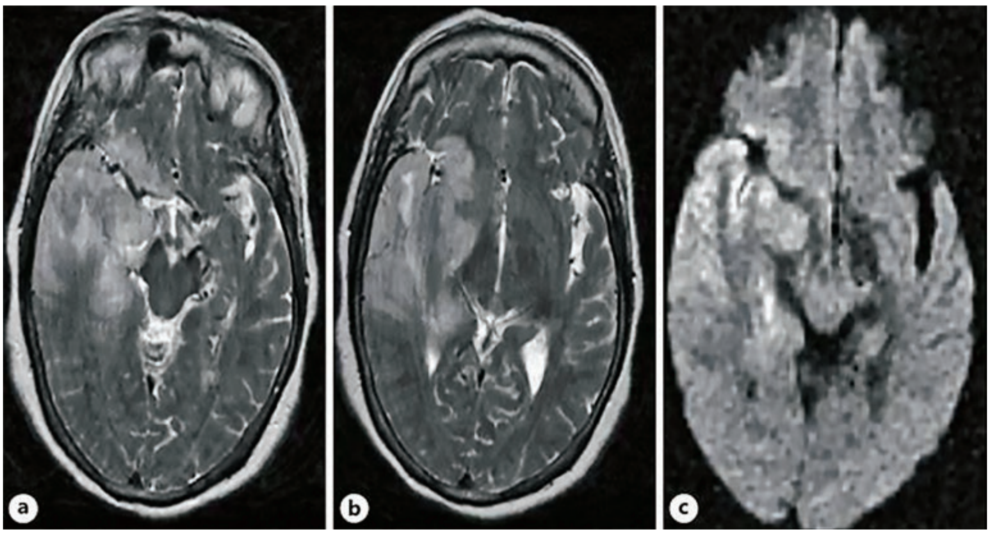


Figure 8. a,b) Axial T2WI shows gyral inflammation and hyperintensities involving the right temporal lobe, posterior aspect of the temporal lobe, and right basal ganglia with restriction of diffusion on the corresponding axial DWI image (c). There is a subtle mass effect on the brainstem with mild leftward midline shift.
Source: https://karger.com/crn/article/15/1/131/845250/Encephalitis-as-a-Clinical-Manifestation-of-COVID

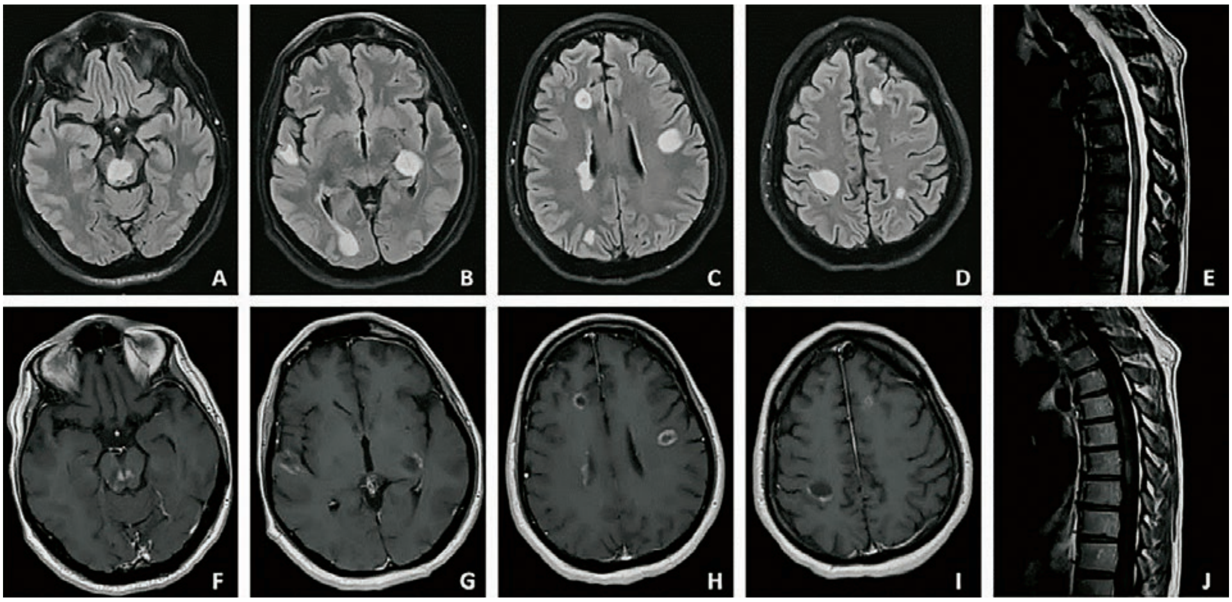


Figure 9. Brain and spinal cord MRI. Brain MRI showing supra- and infratentorial bilateral FLAIR-hyperintense white matter lesions suggestive of ADEM (A–D). In (E) spinal cord MRI documenting a T2-hyperintense dorsal lesion. After gadolinium administration, brain (F–I) and spinal cord (J) are characterized by incomplete contrast enhancement.
Source: https://link.springer.com/article/10.1007/s00415-021-10947-2

IGOS (International GBS Outcome Study) show that 73% of patients experienced sensorimotor symptoms, and 64% had facial nerve palsy [14]. It is believed that in some patients, GBS contributed to difficulties in weaning from mechanical ventilation [17].

In approximately 17.85% of patients who underwent neuroimaging, ischemic changes suggestive of stroke were identified [18]. Many studies confirm the high mortality rate in COVID-positive patients with ischemic stroke, as concluded by Sebastian Fredman and colleagues [19] in a systematic review, where a mortality rate of 45% was observed. The involvement of large blood vessels, particularly the middle cerebral artery (MCA), was most commonly reported. An example of radiological presentation of stroke in a 41-year-old male with COVID-19 infection is shown in Figure 10 [20].

Hematological complications

Changes in hematological parameters can be observed in 20 – 50% of hospitalized COVID-19 patients, who may subsequently develop thrombotic and hemorrhagic complications, more specifically venous and arterial thromboembolisms [21]. In the radiological evaluation of patients suspected of having pulmonary embolism (PE), the CT imaging protocol plays a crucial role, specifically CT pulmonary angiography (CTPA). The imaging protocol, which included the use of an automatic injector to administer 60 ml of contrast at a rate of 4 ml/s and the placement of a trigger to ensure accurate localization with a threshold of 100 HU, resulted in clear visualization of vascular filling defects, which is critical for diagnosing acute pulmonary embolism. Pontone et al. [22] in their study of the role of computed tomography in COVID-19 disease presented the clinical case of an 82-year-old man who presented to the emergency department with symptoms of severe

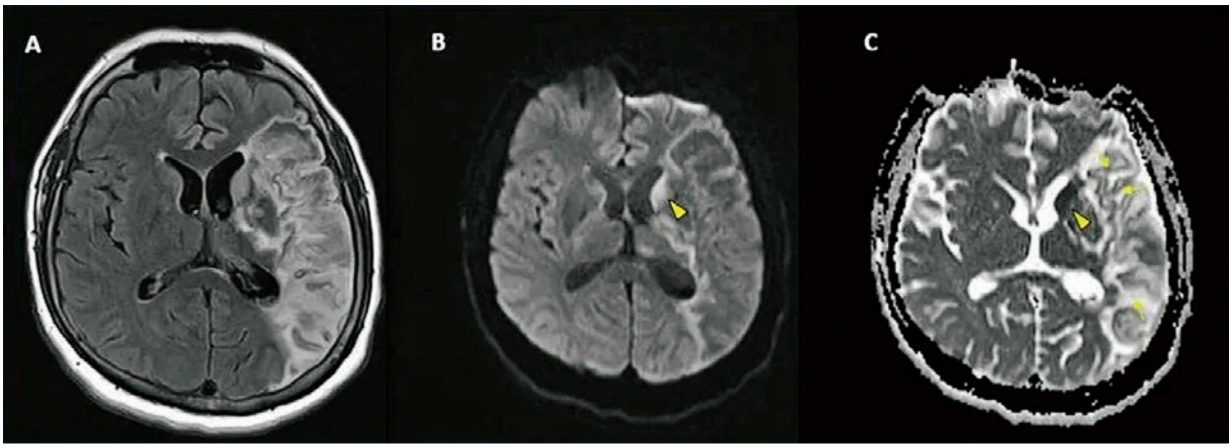


Figure 10. Stroke seen in a 41-year-old male patient with COVID-19 infection.
Source: https://www.itnonline.com/content/large-international-study-reveals-spectrum-covid-19-brain-complications

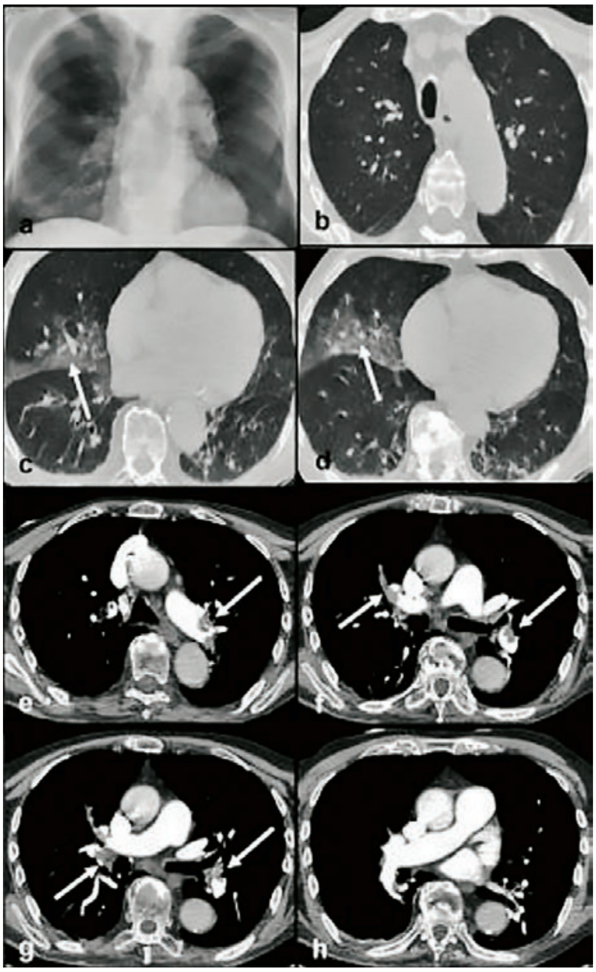


Figure 11. a- AP chest X-ray; b,c,d- axial, non-contrast CT sections show multiple GGO features in both lung fields; e,f,g,h CTPA confirms acute PE.
Source: https://pubmed.ncbi.nlm.nih.gov/32952101/

exertional dyspnea. Blood analysis revealed a significant elevation of D-dimer (7334 ng/ml). The AP chest X-ray showed consolidation in the lower zone of the right lung (Figure 11; a). A CT protocol was performed, consisting of an initial acquisition without contrast (native scan) to evaluate the lung parenchyma, followed by a second acquisition with contrast (contrast-enhanced scan) to assess the pulmonary vasculature (CTPA). Despite the presence of respiratory artifacts that negatively affected image quality, the native CT scan of the chest showed multiple ground-glass opacities (GGO) in both lung fields (Figure 11; b, c, d). The CTPA findings described multiple filling defects in the pulmonary arteries (Figure 11; e, f, g, h), which corresponded to acute PE [22].

Renal complications

The most common renal complications of COVID-19 infection manifest as glomerulonephritis, thrombotic microangiopathy, tubular injury, or interstitial nephritis [23]. Atelj et al. in their professional work described the condition of COVID-19 patients treated in the intensive care unit at the *University Hospital for Infectious Diseases „Dr. Fran Mihaljevic"* and presented data showing that the most frequent complications were shock (66%) and acute renal insufficiency (55%) [24]. The occurrence of renal insufficiency in COVID-19 patients is still not fully understood, and it has been linked to ACE2, the cellular receptor for SARS-CoV-2, which is expressed in both the respiratory epithelium and the kidneys [25]. In cases of renal infarction, ultrasound (US) and contrast-enhanced CT can reveal heterogeneity and hypoperfusion of the renal parenchyma, along with wedge-shaped areas of reduced perfusion (Figure 12) [26].

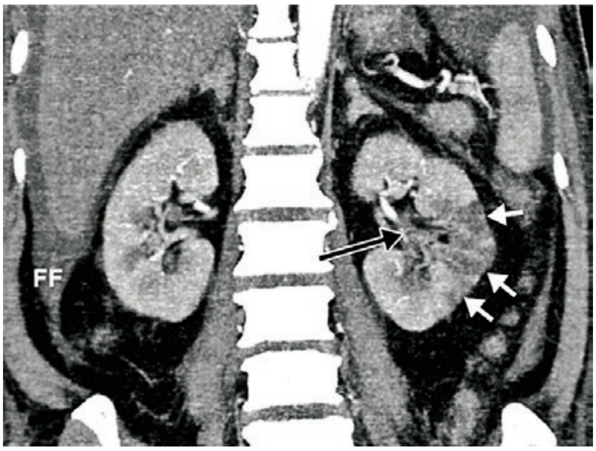


Figure 12. Renal infarction in a 57-year-old male with COVID-19; contrast-enhanced abdominal CT scan shows multiple linear hypoattenuating areas extending from the left renal sinus to the cortical surface (white arrows), with an occlusive thrombus in the segmental left renal artery (black arrow).
Source: https://pubs.rsna.org/doi/full/10.1148/rg.2020200195#fig21

Cardiac complications

The direct vascular effects of the SARS-CoV-2 virus are responsible for myocardial infarction and an increase in the number of sudden out-of-hospital deaths. In addition to myocardial infarction, other damage such as myopericarditis has also been observed. On CT, pericarditis is manifested by the presence of pericardial fluid, accompanied by ground-glass opacity (GGO) opacities characteristic of COVID-19 infection (Figure 13) [27]. An increased incidence of stress cardiomyopathy has also been reported, which is attributed to the indirect involvement of the virus, including the psychological, social, and economic stress associated with the COVID-19 pandemic.

Post-Acute COVID-19 Syndrome

During the ongoing pandemic, persistent symptoms emerged in a large number of patients, becoming characteristic of what is now referred to as "long COVID" (or post-acute COVID-19 syndrome). These symptoms significantly reduce the quality of life, persist for weeks, and can affect nearly every organ system. The most commonly reported symptoms include loss of taste and smell, chronic fatigue, memory and concentration impairments, muscle and joint pain, general weakness, night sweats, headaches, respiratory symptoms such as dyspnea, chest pain, and dry cough, as well as psychiatric issues like asthenia and fatigue.

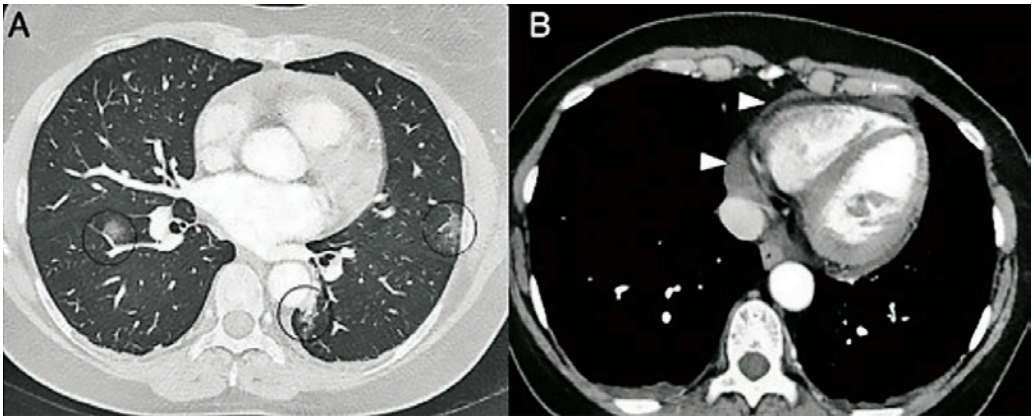


Figure 13. CT scan show GGO opacities (A) and pericardial effusion (tip of the arrows – B).
Source: https://pmc.ncbi.nlm.nih.gov/articles/PMC7687358/

The term “post-acute COVID-19 syndrome,” which refers to the previously described condition, was coined by a patient in May 2020 and first used as a hashtag on the social media platform Twitter. On October 6, 2021, the World Health Organization (WHO) defined “Post-COVID condition” as: “a condition in individuals with a history of probable or confirmed SARS-CoV-2 infection, usually three months after the onset of COVID-19 symptoms, that lasts for at least two months and cannot be explained by an alternative diagnosis” [28]. Recent nomenclature categorizes all post-COVID changes into so-called post-acute sequelae, with subdivisions into short-term (one month post-infection), intermediate-term (2 – 3 months post-infection), and long-term (6 months post-disease onset) [29].

The risks for developing post-COVID syndrome are generally related to the severity of the acute illness, age (particularly over 50), and pre-existing comorbidities. In terms of gender differences, studies show that women are less likely to develop severe acute COVID-19 infection but are more likely to develop post-COVID syndrome compared to men. This is believed to be due to hormonal differences and, consequently, varying immune responses [30].

There is no strictly defined diagnostic protocol for post-COVID syndrome, as the diagnosis is based on a combination of clinical signs and symptoms. The greatest experience in detecting both acute and post-acute changes lies in the radiological evaluation of the lungs. Most patients fully recover from pulmonary involvement, while about 10% develop persistent symptoms. In some patients, cystic lung disease with pneumatocele formation develops (Figure 14). Such persistent symptoms mainly arise as a result of barotrauma during mechanical ventilation [31]. “Fibrosis-like changes” (Figure 14) are significant features of post-COVID syndrome, with predisposition factors including ARDS, non-invasive mechanical ventilation, prolonged hospitalization, extensive abnormalities on the initial CT scan, and age over 50 [32].

Complications of COVID-19 infection in children

In general, children tend to experience a milder form of COVID-19 infection that does not require hospitalization. This can be explained by the fact that children have a higher concentration of ACE2 receptors on pneumocytes, their mucosal immune response is generally more effec-

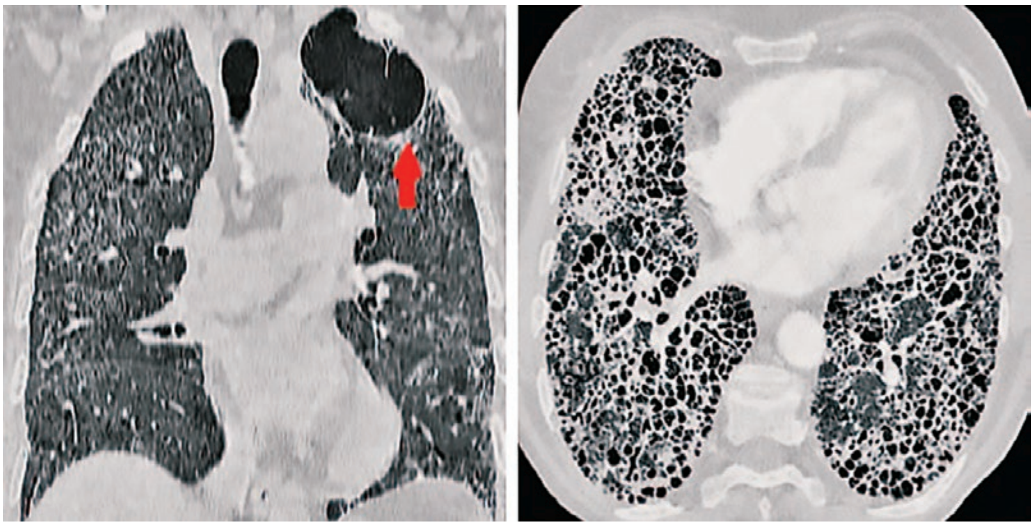


Figure 14. Pneumatocele (red arrow, upper left lobe), six weeks after the diagnosed SARS-CoV-2 infection (left); final stage of fibrosis “honeycombing” after 18 months following recovered COVID pneumonia (right).[29]

tive in preventing infection, and they exhibit a stronger innate antiviral immune response in the upper respiratory tract compared to adults. Hospitalization and admission to intensive care units are necessary for a small percentage of affected children (0.5 – 2%) [4]. Risk factors for developing potential complications of COVID-19 infection in children include neonatal age and comorbidities such as asthma, diabetes mellitus, and obesity.

Extrapulmonary complications are extremely rare, and when they occur, they are typically neurological symptoms such as seizures, Guillain-Barré syndrome (GBS), encephalopathy, or cardiac damage (arrhythmias, myocarditis) of varying severity. Although SARS-CoV-2 typically causes mild clinical symptoms in children, it has led to severe and concerning multisystem inflammatory syndrome in children (MIS-C) in some cases. MIS-C occurs three to six weeks after infection, even if the child was asymptomatic. The incidence of MIS-C is estimated at 1 in 3,000 children, with higher frequencies in children aged 9 to 11 years and in males [4]. The syndrome progresses over several days and involves multisystem involvement, clinically resembling Kawasaki disease. Key MIS-C symptoms include fever, rash, gastrointestinal symptoms, conjunctivitis, and the development of shock due to myocarditis complications. The mortality rate caused by COVID-19 in children is extremely low (0.005 – 0.1%), whereas MIS-C increases the mortality rate to 1.7 – 2% [4].

Conslusion

Radiology played a significant role in the fight against the virus, as its modalities were used for the diagnosis and monitoring of all health changes caused by the infection. Diagnostic modalities such as X-rays, LUS, CT and MRI were tasked with providing patients with timely and appropriate radiological assessment to ensure that potential complications of the disease were identified and treated in a timely manner. To achieve this goal, radiologists and radiologic technologists had to demonstrate a multidisciplinary approach and teamwork to provide the best quality imaging under unusual working conditions, as quickly as possible, while adhering to all protective measures to prevent potential exposure to infection. A special approach was required for patients in intensive care units, whose health status, from an infectious disease perspective, was often insufficiently clear even to modern medicine. Given that severe COVID-19 disease can lead to serious complications, most commonly neurological, treatment in these situations was further complicated by the poorly understood pathophysiological mechanisms of the virus. Published research on the manifestations and complications of COVID-19 highlights the need for further work on comprehensive studies with as much clear, evidence-based data as possible, in order to ensure future results are as precise as possible and to clarify the full range of impacts of the SARS-CoV-2 virus on the human body.

All data in this paper are part of the results from the master's thesis titled 'The role of radiology in the COVID-19 pandemic', written at the University Department of Health Studies, University of Split [33].

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Radiološki modaliteti u otkrivanju, procjeni i praćenju COVID-19 infekcije

Sažetak

Pandemija COVID-19, uzrokovana SARS-CoV-2 virusom, predstavljala je globalni zdravstveni izazov koji je zahtijevao brzu reorganizaciju zdravstvenih sustava i uvođenje strogih zaštitnih mjera. Zlatni standard kod postavljanja dijagnoze COVID infekcije svakako je RT-PCR test, te uz test, radiološke metode koje svojim specifičnim prikazima ukazuju na oboljenja. Radiološki prikaz manifestacija COVID-19 infekcije uključuje radiograme torakalnih organa koji se koriste za evaluaciju plućnih promjena, CT koji pruža detaljan prikaz abnormalnosti uzrokovanim infekcijom, PET/CT i LUS koji dodatno pomažu u dijagnostici i praćenju, te MRI koja se koristi za detaljnu procjenu komplikacija i post covid sindroma. Komplikacije COVID-19 infekcije s najvećom incidencijom su plućne, neurološke, hematološke, bubrežne i srčane. Tijekom pandemije pokazala se njihova ozbiljnost i nepredvidljivost s obzirom da su ishod bolesti dodatno činile neizvjesnim i otežavale oporavak. Posebnu inspiraciju i motivaciju za nova znanstvena istraživanja daju sindrom post covid-a i MIS-C s obzirom da imaju karakteristične značajke kliničke slike.

Ključne riječi: COVID-19; infekcija; komplikacije; manifestacije; radiologija