Role of Plain Radiography, Computed Tomography (CT) and Ultrasound Imaging in Diagnosing Coronavirus Disease-19 (COVID-19): A Narrative Review

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Abstract:

Introduction: The emergence of SARS-CoV-2, commonly referred to as COVID-19, a novel respiratory virus, has had a profound impact on a global scale. Reverse transcription polymerase chain reaction (RT-PCR) serves as the primary diagnostic modality for the detection of COVID-19. Nonetheless, RT-PCR frequently produces a substantial number of false-negative results, necessitating additional diagnostic procedures. The RT-PCR test is employed in conjunction with CT, conventional radiography, and ultrasound for the purpose of diagnosing COVID-19. This study investigated the diagnostic potential of plain radiography, CT, and ultrasound imaging in the detection of COVID-19. **Methods:** The search criteria for this review include articles published recently on diagnostic imaging specialties for the detection of COVID-19. Various databases, such as Web of Science (WoS), PubMed, ScienceDirect, and Google Scholar, were used. **Results:** CT is more sensitive to COVID-19 than conventional radiography and ultrasonography. Even though medical imaging methods are helpful for COVID-19 screening, the virus is typically not detectable in its early stages. The imaging modalities can aid in the screening and follow-up of COVID-19, but they are mostly unable to detect the disease in the early days of infection and therefore cannot be relied upon as standalone tools for determining positive or negative results. Imaging plays an important role in the management of COVID-19 patients by assessing infection severity, controlling disease spread, and improving patient management. The use of imaging modalities introduces certain risks, including the potential for disease spread, difficulty in sanitising large equipment and rooms, and unnecessary radiation exposure for patients. **Conclusion:** The imaging techniques should only be used for follow-up and not as a primary approach to establish whether a person has COVID-19 or not. They can provide valuable information about infection severity and aid in patient management, but precautions should be taken to minimise associated risks.

Keywords: COVID-19, SARS-CoV-2, CT scan, lung ultrasound scanning, chest X-ray, diagnosis

Introduction:

The current concern throughout the world was the emergence of a new virus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a highly infectious sickness known as coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO). The disease can be transferred from person to person and spread by airborne, skin-to-skin, and droplet transmission. According to Guan, et al., (2020), the COVID-19 virus has phylogenetic similarity, and the severity of some cases mimics that of SARS-CoV. It is common for those infected with COVID-19 to have a high temperature, dry cough, extreme exhaustion, and breathing difficulties.

As a common diagnostic procedure, real-time reverse transcription-polymerase chain reaction (RT-PCR) analysis may identify if someone has COVID-19 as a standard diagnostic tool (Chen, et al., 2020). However, due to the shortage of test kit supplies during the peak time of COVID-19 spread and the high false-negative rate of the RT-PCR test, another method can be used to diagnose the disease (Aljondi and Alghamdi, 2020). Tahvildari, et al., (2020) stated that chest imaging can be used for detecting and assessing COVID-19 progress. According to several studies, conventional radiography, computed tomography (CT), and ultrasound are all imaging modalities that can be used to diagnose COVID-19.

Early detection is crucial in controlling the spread of the COVID-19 infection. In chest imaging, the time taken for diagnosis is shorter compared to waiting for the RT-PCR test result, where it takes several days for the analysis to be done. The information gathered using chest imaging can contribute to the early intervention and assessment of the disease. Nevertheless, different modalities bring different positive predictive values (PPV) and negative predictive values (NPV) as the sensitivity of the system is different from one another (Shammus, et al., 2020). We looked at the three imaging modalities (plain radiography, CT, and ultrasound imaging) that may be used to detect COVID-19 and how significant they are for reaching a diagnosis in this narrative review paper.

We searched several databases to find most recent publications for our review paper. These databases included Web of Science (WoS), PubMed, ScienceDirect, and Google Scholar. All of the articles and publications that were found to be pertinent during the searches were for the year 2020. COVID-19, role, diagnosis, radiography, CT, and ultrasound imaging were employed as key terms.

Coronavirus Disease 2019 (COVID-19) and Diagnostic Techniques

A new coronavirus emerged in December 2019 and expanded worldwide. It began in Wuhan, Hubei, and expanded from there. SARS-CoV-2, subsequently renamed COVID-19, causes severe acute respiratory syndrome. According to Guan et al. (2020), the new virus has a phylogenetic similarity and the severity of some cases mimicked that of SARS-CoV. COVID-19 spread widely to different countries in no time, causing the total number of infection cases around the world to increase rapidly. The World Health Organization classified COVID-19 a pandemic in March 2020.

COVID-19 can be transferred from person to person and spread by airborne, skin-to-skin contact, and droplet transmission. Anyone has the possibility of getting infected if the spread is not controlled and no precautionary measures are taken. For people with chronic diseases such as diabetes, the probability of getting infected by COVID-19 is rather high compared to healthy people, as the immune systems of people with chronic diseases are degraded or weak. The severity of infection and mortality rate are also high for this type of patient if infected with COVID-19. Therefore, to avoid the spread of COVID-19, a swab test and quarantine are required for a person that travels to or from a highly infected place, has a record of contact with the infected patient, and develops typical symptoms of COVID-19 such as fever, dry cough, the gradual development of dyspnea, and fatigue. The symptoms that develop are due to respiratory disruption, which can advance to severe pulmonary damage.

In a swab test, a sample is collected using a long swab that is inserted through the nose or mouth into the nasopharyngeal or oropharyngeal cavity. Later, this specimen is tested in the laboratory using a standard diagnostic tool known as real-time reverse transcription-polymerase chain reaction (RT-PCR) analysis (Chen, et al., 2020). However, this tool has the major drawback of showing high false-negative results for tests conducted. This is believed to be caused by the error in the detection and extraction process during the nasopharyngeal swab test sampling. In addition, Jiang, et al., (2020) mentioned that the nasopharyngeal sample has a lower diagnostic value than the lower respiratory tract sample due to the inadequacy of cellular material

collected. Unfortunately, the lower respiratory tract sample is difficult to acquire and may cause more harm to the patient.

The number of cases recorded for COVID-19 around the globe kept on increasing dramatically during the first quarter of 2020. As many cases were reported during the early part of 2020, especially from February to April, Akl, et al., (2020) stated that RT-PCR test kit supplies were running low, making the detection of COVID-19 limited. Early diagnosis of the contagious disease can help in isolation and treatment arrangements for suspected patients. Regrettably, the result using RT-PCR analysis takes a bit of time before it can be confirmed and revealed. This delays early detection and treatment for certain individuals, which increases COVID-19 spread. The RT-PCR analysis is unable to provide details on the progress of infection and is only limited to giving a true or false answer to the presence of COVID-19 infection in suspected patients. With high false-negative rates, misdiagnosis of patients' status cannot be avoided.

Materials and Methods:

This study endeavoured to gather a comprehensive selection of pertinent articles from various databases, including the WoS, PubMed, ScienceDirect and Google Scholar. The study employed keyword searches in various databases to identify pertinent content. The selection of keywords was derived from the research objectives. The terms COVID-19, role, diagnosis, radiography, CT, and ultrasound imaging were used. Search results were enhanced by combining terms with the Boolean operators AND, OR, and NOT.

The study used specific inclusion and exclusion criteria to select relevant articles on the role of medical imaging techniques in diagnosing COVID-19. Inclusion criteria were used to identify articles that met specific requirements, while exclusion criteria were used to filter out unrelated or irrelevant articles to ensure that relevant and appropriate literature was selected for analysis. These criteria assisted in eliminating unrelated or extraneous articles and concentrating on those that directly addressed the review's objectives. Too broad criteria may result in a large volume of articles that need to be reviewed, making it challenging and time-consuming. On the other hand, too narrow criteria may exclude potentially valuable research. Table 1 provides the specific details regarding the inclusion and exclusion criteria.

Results:

A comprehensive search resulted in the identification of 521 articles that were deemed relevant to the study. Following a thorough evaluation of the titles and abstracts, a total of 490 articles were determined to be ineligible for incorporation into the study. As an outcome, a total of 31 articles were found to be suitable for inclusion in the study. Furthermore, the stringent selection process involved evaluating relevant full papers aligned with the study's aims and research inquiry, resulting in the exclusion of 14 articles. As a result, a total of 17 articles met the established criteria for inclusion in the analysis. Figure 1 illustrates the procedures involved in selecting relevant articles.

Table 1. Article selection criteria for inclusion and exclusion

Inclusion Criteria	**Exclusion Criteria**
Articles published in the year 2020.	Articles published in the years 2021–2023.
Articles on the diagnosis of COVID-19 using plain radiography, CT, and ultrasound imaging techniques.	Articles discussing the use of Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT), Magnetic Resonance Imaging (MRI), SPECT/CT, PET/CT, and PET/MRI in the diagnosis of COVID-19.
Full articles only.	Abstracts.
Articles written in English.	Articles written in languages other than English.

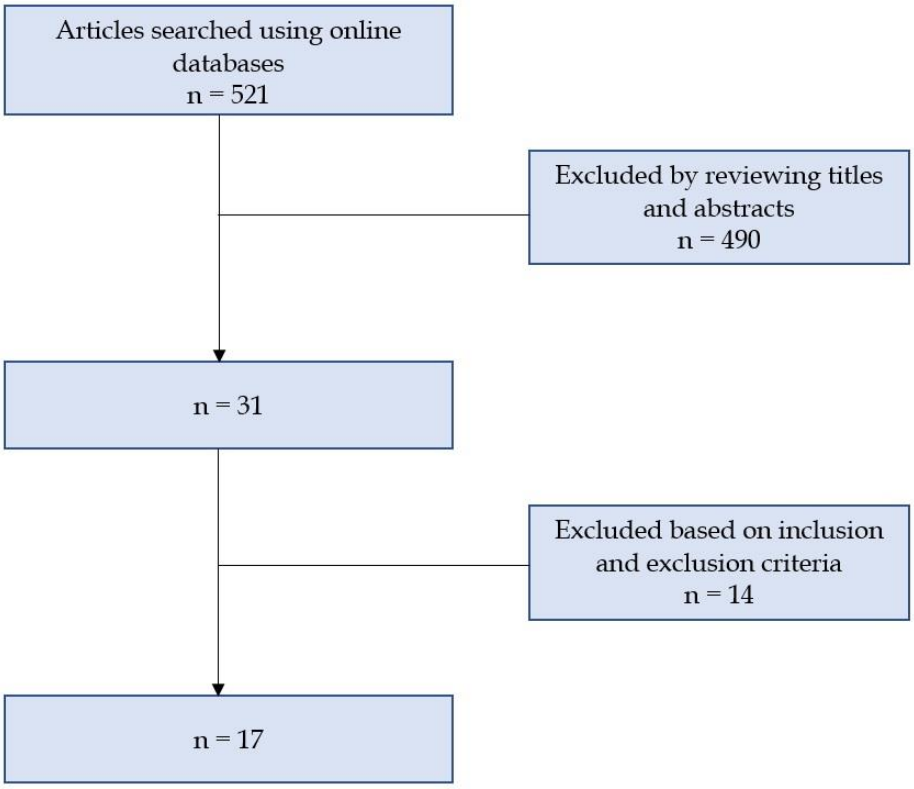

Figure 1. Search and selection process of articles.

The selected articles that fulfilled the predetermined criteria are shown in Table 2.

Table 2. Details of selected articles

Author (s) and year of publication	**Title**	**Type of study**	**Country**	**Themes**
Ai, et al., 2020	Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases.	Retrospective Study	China	Diagnostic Value and Correlation of Chest CT and RT-PCR.
Akl, et al., 2020	Use of Chest Imaging in the Diagnosis and Management of COVID-19: A WHO Rapid Advice Guide.	Review/Survey	Switzerland	Chest Imaging (chest radiography, chest CT and lung Ultrasound) in the Diagnosis and Management of COVID-19.
Aljondi, and Alghamdi, 2020	Diagnostic Value of Imaging Modalities	Scoping Review	Saudi Arabia	Diagnostic Value of chest CT, lung ultrasound, chest x-ray and positron emission

	for COVID-19: Scoping Review.			tomography/computed tomography (PET/CT) for the diagnosis of COVID-19.
Chen, et al., 2020	Use of Radiographic Features in COVID-19 Diagnosis.	Review	China	The utilisation of radiographic features of Chest CT and X-ray scans in the diagnosis of COVID-19.
Farias, et al., 2020	Imaging findings in COVID-19 pneumonia.	Review	Brazil	The diagnostic efficacy of chest radiography, CT, and ultrasonography in detecting COVID-19.
Fang, et al., 2020	Sensitivity of Chest CT for COVID-19: Comparison to RT-PCR. Radiology.	Clinical Study / Experimental	China	Sensitivity of Chest CT for COVID-19 Vs RT-PCR.
Gandhi, et al., 2020	Current role of imaging in COVID-19 infection with recent recommendations of point of care ultrasound in the contagion: a narrative review.	A Narrative Review	USA	The role of imaging modalities in COVID-19 detection (plain radiography, CT, and ultrasound).
Huang, et al., 2020	Serial Quantitative Chest CT Assessment of COVID-19: A Deep Learning Approach.	Retrospective Study	China	Investigations into the alterations in lung burden among individuals diagnosed with coronavirus disease 2019 (COVID-19) through the utilisation of serial CT scans, employing an automated deep learning technique.
Jiang, et al., 2020	The Role of Imaging Techniques in Management of COVID-19 in China: From Diagnosis to Monitoring and Follow-Up.	Review	China	Chest radiography, CT, ultrasound, and PET/CT scans are utilised to diagnose and treat COVID-19.
Kanne, 2020	Chest CT Findings in 2019 Novel Coronavirus (2019-nCoV) Infections from Wuhan, China: Key	Review	China	Chest CT Findings in COVID-19.

	Points for the Radiologist.			
Li, et al., 2020	CT image visual quantitative evaluation and clinical classification of coronavirus disease (COVID-19).	Retrospective Single-centre Study	China	Correlation between COVID-19's imaging characteristics (CT scans) and its clinical categorization.
Roshkovan, et al., 2020	The Role of Imaging in the Management of Suspected or Known COVID-19 Pneumonia. A Multidisciplinary Perspective.	Review	USA	Utilising thoracic imaging modalities (X-ray, CT and ultrasound) appropriately to guide clinical management of COVID-19.
Rubin, et al., 2020	The Role of Chest Imaging in Patient Management during the COVID-19 Pandemic: A Multinational Consensus Statement from the Fleischner Society.	Radiologists and Pulmonologists Report	USA	Guidelines for the use of chest radiography and CT in the management of COVID-19 by medical practitioners.
Shammus, et al., 2020	The role of imaging and other diagnostic approaches in COVID-19.	Review	UK	To examine and compare RT-PCR, serum inflammatory biomarkers, chest radiographs, ultrasound, and chest CT scans for COVID-19 diagnosis in asymptomatic individuals.
Smith, et al., 2020	Point-of-care lung ultrasound in patients with COVID -19 – a narrative review.	A Narrative Review	UK	Lung ultrasonography usage and interpretation for moderate, severe, and critical COVID-19–associated lung damage.
Sohail, 2020	Radiology of COVID-19: Imaging the pulmonary damage.	A Brief Commentary	Pakistan	The imaging modalities (X-ray, CT and mobile ultrasound) for COVID-19 pneumonia screening, diagnosis, and management.
Tahvildari, et al., 2020	Clinical Features, Diagnosis, and Treatment of COVID-19 in Hospitalized	A Systematic Review	Iran	Diagnosis of COVID-19 in Hospitalized Patients using CT.

	Patients: A Systematic Review of Case Reports and Case Series.

Medical Imaging Modalities for the Diagnosis of COVID-19

Indeed, imaging modalities play a big role in addition to RT-PCR in detecting and diagnosing COVID-19. The RT-PCR can only answer the question of whether someone tested using the test kit is infected with COVID-19 or not. The imaging modalities, however, can elaborate on details of the disease and are now used to screen, assess, and monitor the progress and severity of infection in patients with a positive COVID-19. Chest imaging can provide important diagnostic information that can aid in the intervention and treatment of a patient's condition. Early intervention can reduce the mortality rate among infected patients. Moreover, when early intervention is given to the positive COVID-19 patients, the spread of the disease can be controlled. This is because early intervention can prevent the patients from making close contact with different people in the society where they are working, studying, or just socializing. Patients with a positive COVID-19 test result are often admitted to the nearest hospital for further evaluation and medical management. The pathophysiology of COVID-19 can also be better understood with the help of imaging tools. By assessing the image appearances, more studies can be conducted to see the similarity to the previous existing disease. Understanding pathophysiology can also help in determining the best therapy for different types of patients. More accurate diagnostic methods and tools for detecting and diagnosing COVID-19 can be established. Researchers may use chest imaging data to construct a new golden tool to differentiate COVID-19 similar to SARS and Middle East Respiratory Syndrome (MERS) infections. Chest imaging provides new insights into the characteristics of the virus and disease, which are crucial in the development of standard guidelines and protocols for any query of COVID-19 cases and new therapeutic agents for the recovery of the patients. Besides, the imaging can help physicians and healthcare providers see whether the treatment given to patients is useful to reduce the spread of the infection, pulmonary damage, interstitial inflammation, pleural effusion, and cardiac shock.

While debates on the use of imaging modalities for COVID-19 confirmation continue for several reasons, the shortage of test kits pushes the debate to a halt. Moreover, the accuracy of RT-PCR analysis gives higher false-negative results, especially on specimens taken during the initial days of infection, making the early detection of COVID-19 difficult. Besides, more articles mentioning the use of imaging modalities in detecting COVID-19, in addition to RT-PCR, are published. Akl, et al., (2020) reported that the WHO developed a quick guide on the use of chest imaging in COVID-19 diagnosis and treatment. While in various publications, the most mentioned imaging modalities in recent articles include plain radiography, computed tomography (CT), and ultrasound. These imaging modalities have different accuracy rates and different diagnostic values. This may be caused by the examination period that takes time and is not suitable for screening patients. Long periods of close contact and interaction between health care workers and patients suspected of having COVID-19 in the radiology department can make it more likely that the infection will spread.

Farias, et al., (2020) and Roshkovan, et al., (2020) stated in their article that chest imaging for patients with asymptomatic or mild symptoms of COVID-19 generally should not be recommended and reserved only for those who are present with moderate to severe symptoms of respiratory worsening progression regardless of the RT-PCR results. However, in an environment with limited resources, Li, et al., (2020) argued that imaging can eventually be indicated for patients suspected of COVID-19 in which urgent decision-making is the priority. In the study conducted by Ai, et al., (2020) and Chen, et al., (2020), computed tomography (CT) is said to be able to outperform the sensitivity of detecting COVID-19 compared to the RT-PCR test in asymptomatic patients.

Plain Radiography

Most of the literature found on the relationship of imaging modalities and COVID-19 focused on the importance of CT as the standard imaging modality in the detection of the disease due to the high sensitivity of the imaging modality. After many years, chest radiography and ultrasound imaging are now also considered to be used in the diagnosis of patients with suspected COVID-19. Chen, et al., (2020) state that initially, chest radiography was performed for quick screening of patients with suspected COVID-19 due to the overcrowded emergency room. Compared to CT

scans, chest radiography is easily accessible as it is a must-have system in the radiology department. Besides, due to the low cost of the imaging system, fast image acquisition, and simple method of use, plain radiography is frequently requested. Even so, Gandhi, et al., (2020) specified that chest radiography has a lower sensitivity value for early onset of COVID-19 and might produce a normal image appearance even when chest CT, which is performed at the same time, produces a ground-glass opacity image.

Chest radiographs of COVID-19 patients show pulmonary infiltration, bilateral peripheral consolidation of lower lung areas, and ground-glass opacities, similar to CT (Shammus, et al., 2020). The severity of COVID-19 infection might impose a different image appearance where mild cases show pulmonary damage to the right lung only and severe cases damage both lungs. COVID-19 patients are usually accompanied by right pulmonary damage in the early stages of infection before the severity increases and infection starts to spread to the whole lung (Rubin, et al., 2020; Sohail, 2020). Although most chest radiographs are unable to give a diagnosis for the disease in the onset period, literature discussing the use of this imaging implies that it can be indicated for patients' follow-up in order to reduce radiation exposure given using CT scans. Shammus, et al., (2020) observed that the abnormal patterns seen in chest radiographs are severe during the 10 - 12 days from symptoms onset where the diagnosis is comparable to CT findings in the 6-11 days.

Computed Tomography (CT)

Ai, et al., (2020) and Fang, et al., (2020) found that CT scan may be utilized to diagnose highly suspected individuals with negative RT-PCR test results but clinical signs or an epidemiologic history of COVID-19. Even though the sensitivity of CT imaging improves with the progression of the disease, Shammus, et al., (2020) argued that due to the possibility of normal image appearance in the early stages of COVID-19, CT might also give negative predictive value. Gandhi, et al., (2020), reported that, 50% of positive COVID-19 patients may have normal image appearance in their CT findings during the early onset (Wu, et al., 2020). Still, a negative CT scan result does not give a reason for patients with clinical symptoms and exposure or travel history to be excluded from COVID-19 diagnosis and quarantine mandate. As a result, relying solely on chest CT to rule out COVID-19 infection cannot be relied upon, especially if the examination is performed in the early stages.

During the hospital admission of patients with COVID-19, they are usually diagnosed with pneumonia, followed by adult respiratory distress syndrome (ARDS), and pulmonary or cardiac shock (Guan, et al., 2020). Different pathogens generate pneumonias that look like COVID-19 on CT. Therefore, differentiating patients with COVID-19 and other pneumonia is difficult. Fortunately, there was a study conducted to compare pneumonia with non-COVID-19 infection and with the infection. According to Jiang, et al., (2020), COVID-19 pneumonia was more likely to show peripheral ground-glass opacities (GGOs) and reticular interlobular septal thickening than central distributions, pleural effusion, and lymphadenopathy. RT-PCR analysis should also be performed on a positive COVID-19 diagnosis to confirm the infection. A chest CT is a reliable, practical, and fast way to diagnose COVID-19, especially in epidemic regions, but it cannot be used alone (Jiang, et al., 2020).

Gandhi, et al., (2020) reported GGOs with superimposed inter- and intralobular lines (crazy-paving) pattern in CT scans of COVID-19 patients during early infection (0–5 days). In early COVD-19 infection, chest CT images show GGOs with irregular linear opacities and interfaces. Patients with long-term symptoms may also show consolidations, complete lung disease, bilateral patchy shadowing, peripheral distribution, and reverse "halo sign" on CT, depending on the infection phase (Gandhi, et al., 2020; Guan, et al., 2020; Roshkovan, et al., 2020; Shammus, et al., 2020). According to a study done by Zu, et al., (2020), Lee, (2020), Kanne, et al. (2020), and Wu, et al., (2020), bronchial wall thickening, pleural or pericardial effusion, and lymphadenopathy are not very common side effects of COVID-19.

Ultrasound Imaging

Another alternative to diagnosing early-stage pneumonia besides chest radiography and chest CT is lung ultrasound. In Mojoli, et al., (2019), lung ultrasound imaging was found to be more accurate and better in identifying common pathologies related to the lungs, such as pneumothorax, consolidation, and pleural effusion, than that of chest radiography diagnostic. In a 2017 European Respiratory journal study of 55 patients, chest ultrasonography exhibited 100% sensitivity and 98.2% accuracy in diagnosing pneumonia, compared to chest radiography, which had 74.4% sensitivity and 63.3% accuracy (Gandhi, et al., 2020). Shammus, et al., (2020) noted that the latest ultrasound probes may be used to assess patients at

home, minimizing the overcrowding in health facilities.

The discussion of using ultrasound to diagnose COVID-19 has deepened due to the fear of infection transmission regarding the transportation of patients to the CT or radiography rooms (Gandhi, et al., 2020). In positive COVID-19 patients, their lungs will undergo alveolar damage and edema, signs of pneumonia, which begin in the distal parts of the lungs before progressing proximally (Smith, et al., 2020). Huang, et al., (2020) mentioned that the assessment of COVID-19 pneumonia progression is suited as lung ultrasound uses surface imaging techniques. At the same time, the ultrasound of the lung has specific features to distinguish bacterial pneumonia and COVID-19 pneumonia image appearances (Aljondi and Alghamdi, 2020). In normal and healthy lungs, the sonographic appearance will show A-lines echo, which are transverse parallel hyperechoic lines (Gandhi, et al., 2020). Interstitial thickening and inflammation generate pleural line abnormalities and B-line artifacts in COVID-19 (Smith, et al., 2020; Sohail, 2020).

Ultrasound detects COVID-19 lung lesions better than chest radiography and delivers findings similar to chest CT (Smith, et al., 2020). Jiang, et al., (2020) reported that POCUS cannot identify deep lung lesions because the aerated lung blocks sound waves since air is a poor medium for sound waves. In this matter, the use of CT scans will play an important part in determining the severity of the disease. Meanwhile, special care must be taken when using radiation for the diagnosis and management of pregnant women who test positive for COVID-19 (Aljondi and Alghamdi, 2020), and they express regret that there aren't many articles on the subject.

Discussion:

The significant role that medical imaging techniques have played in the diagnosis of COVID-19. These imaging modalities include plain radiography, computed tomography (CT), and ultrasound. While the reverse transcription-polymerase chain reaction (RT-PCR) test remains the primary method for confirming a COVID-19 infection, medical imaging provides additional valuable information about the disease (Akl et al., 2020; Farias et al., 2020; Aljondi and Alghamdi, 2020; Smith et al., 2020; Gandhi et al., 2020). Furthermore, medical imaging techniques have been utilized to aid in the diagnosis, understanding, and monitoring of COVID-19 cases. They may help healthcare professionals assess the severity of the infection, identify complications, and guide treatment decisions (Aljondi and Alghamdi, 2020; Smith, et al., 2020; Gandhi, et al., 2020).

Plain radiography, also known as chest X-rays, has been used for quick screening of patients with suspected COVID-19, especially in settings with limited resources. It is easily accessible, cost-effective, and provides fast image acquisition. However, chest radiography has lower sensitivity compared to CT scans, particularly in the early stages of the disease (Guan, et al., 2020; Shammus, et al., 2020; Roshkovan, et al., 2020). Normal chest X-ray findings do not rule out COVID-19, and abnormalities may become more apparent as the disease progresses. Chest radiographs of COVID-19 patients typically show pulmonary infiltration, bilateral peripheral consolidation, and ground-glass opacities (GGOs) similar to CT. Chest radiography can be used for patient follow-up to reduce radiation exposure from CT scans but should not be solely relied upon for diagnosis.

CT scans have been widely used to diagnose individuals suspected of having COVID-19 but tested negative on RT-PCR, especially if they show symptoms or have a history of exposure (Ai, et al., 2020; Fang, et al., 2020). CT scans are more sensitive than RT-PCR, particularly in asymptomatic patients. However, in the early stages of the disease, CT scans may not detect abnormalities, leading to false-negative results (Ai, et al., 2020; Fang, et al., 2020). Therefore, a negative CT scan does not rule out COVID-19, especially in symptomatic patients with exposure or travel history. CT scans can show specific findings like ground-glass opacities, interlobular septal thickening, and lung consolidations, helping differentiate COVID-19 from other types of pneumonia (Gandhi, et al., 2020; Jiang, et al., 2020). Although CT is valuable for COVID-19 diagnosis, it should not be solely relied upon and should be used in conjunction with other diagnostic methods (Jiang, et al., 2020).

Ultrasound imaging, specifically lung ultrasound has emerged as an alternative method for diagnosing early-stage pneumonia in COVID-19 patients (Huang, et al., 2020). Lung ultrasound has shown high accuracy in identifying lung pathologies, including pneumonia (Smith, et al., 2020). It has been found to be more accurate than chest radiography in diagnosing pneumonia in general. Lung ultrasound can be particularly useful in minimizing the risk of infection transmission during patient transportation to radiography or CT room (Gandhi, et al., 2020). It can detect COVID-19 lung lesions and provide findings similar to CT scans. The characteristic features observed in lung ultrasound include interstitial

thickening, inflammation, pleural line abnormalities, and B-line artifacts (Aljondi and Alghamdi, 2020; Smith, et al., 2020; Sohail, 2020). However, it is important to note that lung ultrasound may not be able to identify deep lung lesions, and CT scans may still be necessary to determine the severity of the disease.

The use of medical imaging techniques in the diagnosis of COVID-19 has its limitations and considerations. Chest radiography and CT scans should not be used as standalone diagnostic methods, and a confirmed diagnosis still requires RT-PCR testing. False-negative results can occur in the early stages of the disease, and normal imaging findings do not exclude a COVID-19 diagnosis. The choice of imaging modality depends on the availability of resources, the severity of symptoms, and the specific clinical context. Additionally, precautions should be taken when using radiation-based imaging techniques, especially in vulnerable populations such as pregnant women.

Medical imaging modalities, such as plain radiography, computed tomography (CT), and ultrasound, have significantly contributed to the detection and management of COVID-19. They provide additional diagnostic information, aid in disease monitoring and severity assessment, and can help differentiate COVID-19 from other respiratory conditions. However, they should be used in conjunction with RT-PCR testing and clinical evaluation to ensure accurate diagnosis and appropriate patient management.

Conclusion:

RT-PCR is the current gold standard for determining the positive or negative status of COVID-19. However, it can produce false negatives and lacks the ability to provide detailed information about the infection spread and progress. Imaging modalities such as plain radiography, CT, and ultrasound are used to assess and provide more accurate diagnoses of COVID-19 severity. CT has the highest sensitivity, followed by plain radiography and ultrasound. While imaging modalities can aid in the screening and follow-up of COVID-19, they are mostly unable to detect the disease in the early days of infection, and therefore cannot be relied upon as standalone tools for determining positive or negative results. The utilisation of medical imaging techniques is of paramount importance in the effective management and treatment of COVID-19 patients by assessing infection severity, controlling disease spread, and improving patient management. The use of imaging modalities introduces certain risks, including the potential for disease spread, difficulty in sanitizing large equipment and rooms, and unnecessary radiation exposure for patients. To mitigate these risks, precautionary measures should be taken, such as providing dedicated examination areas, utilizing smaller and portable modalities, and using ultrasound scans to reduce radiation doses to patients. In summary, imaging modalities have important roles in managing COVID-19 patients, but they should be used in conjunction with other diagnostic methods like RT-PCR. They can provide valuable information about infection severity and aid in patient management, but precautions should be taken to minimize associated risks.

References:

Ai, T., Yang, Z., Hou, H., Zhan, C., Chen, C., Lv, W., et al. (2020). Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases. Radiology. 296(2):E32 - E40. Epub 2020/02/26. doi: 10.1148/radiol.2020200642.

Akl, E. A., Blazic, I., Yaacoub, S., Frija, G., Chou, R., Appiah, J. A., Fatehi, M., Flor, N., Hitti, E., Jafri, H., Jin, Z.-Y., Kauczor, H. U., Kawooya, M., Kazerooni, E. A., Ko, J.P., Mahfouz, R., Muglia, V., Nyabanda, R., Sanchez, M., Perez, M. R. (2020). Use of Chest Imaging in the Diagnosis and Management of COVID-19: A WHO Rapid Advice Guide. Radiology. 203173. https://doi.org/10.1148/radiol.2020203173.

Aljondi, R., and Alghamdi, S. (2020). Diagnostic Value of Imaging Modalities for COVID-19: Scoping Review. Journal of Medical Internet Research. 22(8), e19673. https://doi.org/10.2196/19673

Chen, S. G., Chen, J.Y., Yang, Y.P., Chien, C.S., Wang, M.L., & Lin, L.T. (2020). Use of Radiographic Features in COVID-19 Diagnosis. Journal of the Chinese Medical Association. 83(7), 644–647. https://doi.org/10.1097/jcma.0000000000000336

Farias, L. P. G., Fonseca, E. K. U. N., Strabelli, D. G., Loureiro, B. M. C., Neves, Y. C. S., Rodrigues, T. P., Chate, R. C., Nomura, C. H., Sawamura, M. V. Y., and Cerri, G. G. (2020). Imaging findings in COVID-19 pneumonia. Clinics. 75, e2027.https://doi.org/10.6061/clinics/2020/e2027

Fang, Y., Zhang, H., Xie, J., Lin, M., Ying, L., Pang, P., et al. (2020). Sensitivity of Chest CT for COVID-19:

Comparison to RT-PCR. Radiology. 200432. doi: 10.1148/radiol.2020200432. PubMed PMID: 32073353.

Gandhi, D., Jain, N., Khanna, K., Li, S., Patel, L., and Gupta, N. (2020). Current role of imaging in COVID-19 infection with recent recommendations of point of care ultrasound in the contagion: a narrative review. Annals of Translational Medicine, 8(17), 1094. https://doi.org/10.21037/atm-20-3043

Guan, W., Ni, Z., Hu, Y., Liang, W., Ou, C., He, J., Liu, L., Shan, H., Lei, C., Hui, D. S. C., Du, B., Li, L., Zeng, G., Yuen, K.Y., Chen, R., Tang, C., Wang, T., Chen, P., Xiang, J., Zhong, N. (2020). Clinical Characteristics of Coronavirus Disease 2019 in China. New England Journal of Medicine. 382(18), 1708–1720.https://doi.org/10.1056/nejmoa2002032

Huang, L., Han, R., Ai, T., Yu, P., Kang, H., Tao, Q., et al. (2020). Serial Quantitative Chest CT Assessment of COVID-19: A Deep Learning Approach. Radiology: Cardiothoracic Imaging. 2(2):e200075.

Jiang, Z., He, C., Wang, D., Shen, H., Sun, J., Gan, W., Lu, J., and Liu, X. (2020). The Role of Imaging Techniques in Management of COVID-19 in China: From Diagnosis to Monitoring and Follow-Up. Medical Science Monitor. 26, e924582-1-e924582-10. https://doi.org/10.12659/msm.924582

Kanne, J.P. (2020). Chest CT Findings in 2019 Novel Coronavirus (2019-nCoV) Infections from Wuhan, China: Key Points for the Radiologist. Radiology. 200241. doi: 10.1148/radiol.2020200241.

Lee, S.A. (2020). Coronavirus Anxiety Scale: A brief mental health screener for COVID-19 related anxiety. Death Stud. 44(7):393-401. doi: 10.1080/07481187.2020.1748481.

Li, K., Fang, Y., Li, W., Pan, C., Qin, P., Zhong, Y., et al. (2020). CT image visual quantitative evaluation and clinical classification of coronavirus disease (COVID-19). Eur Radiol. 30(8):4407-16. doi: 10.1007/s00330-020-06817-6.

Mojoli, F., Bouhemad, B., Mongodi, S., Lichtenstein, D. (2019). Lung Ultrasound for Critically Ill Patients. Am J Respir Crit Care Med. 15;199(6):701-714.

Roshkovan, L., Chatterjee, N., Galperin-Aizenberg, M., Gupta, N., Shah, R., Barbosa, E. M., Simpson, S., Cook, T., Nachiappan, A., Knollmann, F., Litt, H., Desjardins, B., Jha, S., Panebianco, N., Baston, C., Thompson, J. C., and Katz, S.I. (2020). The Role of Imaging in the Management of Suspected or Known COVID-19 Pneumonia. A Multidisciplinary Perspective. Annals of the American Thoracic Society. 17(11), 1358–1365. https://doi.org/10.1513/annalsats.202006-600fr

Rubin, G.D., Ryerson, C.J., Haramati, L.B., Sverzellati, N., Kanne, J.P., Raoof, S.,Schluger, N.W., Volpi, A., Yim, J.J., Martin, I.B.K., Anderson, D.J., Kong, C., Altes, T., Bush, A., Desai, S.R., Goldin, O., Goo, J.M., Humbert, M., Inoue, Y., Leung, A.N. (2020). The Role of Chest Imaging in Patient Management during the COVID-19 Pandemic: A Multinational Consensus Statement from the Fleischner Society. Radiology. 296(1), 172–180. https://doi.org/10.1148/radiol.2020201365

Shammus, R., Mahbub, S., Rauf, M. A., and Harky, A. (2020). The role of imaging and other diagnostic approaches in COVID-19. Acta Biomed. 91(3), e2020019. ttps://doi.org/10.23750/abm.v91i3.9822

Smith, M. J., Hayward, S. A., Innes, S. M., and Miller, A. S. C. (2020). Point-of-care lung ultrasound in patients with COVID -19 – a narrative review. Anaesthesia. 75(8), 1096–1104. https://doi.org/10.1111/anae.15082

Sohail, S. (2020). Radiology of COVID-19: Imaging the pulmonary damage. Journal of the Pakistan Medical Association. 70(5), S60–S63. https://doi.org/10.5455/jpma.21

Tahvildari, A., Arbabi, M., Farsi, Y., Jamshidi, P., Hasanzadeh, S., Calcagno, T. M., Nasiri, M. J., and Mirsaeidi, M. (2020). Clinical Features, Diagnosis, and Treatment of COVID-19 in Hospitalized Patients: A Systematic Review of Case Reports and Case Series. Frontiers in Medicine. 7, 231. https://doi.org/10.3389/fmed.2020.00231

WHO. WHO Director-General's remarks at the media briefing on 2019-nCoV on 11 February 2020. https://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020 (WHO, 11 February 2020).

Wu, F., Zhao, S., Yu, B. et al. (2020). A new coronavirus associated with human respiratory disease in

China. Nature. 579, 265–269. https://doi.org/10.1038/s41586-020-2008-3

Zu, Y. Z., Jiang, M. D., Xu, P. P., Chen, W., Ni, Q. Q., Lu, G. M., Zhang, L. J. (2020). Coronavirus Disease 2019 (COVID-19): A Perspective from China. Radiology. 296(2):E15-E25. doi: 10.1148/radiol.2020200490.