MAGNETIC RESONANCE IMAGING AND HYBRID IMAGING APPROACHES FOR ASSESSING COVID-19 DISEASE PROGRESSION AND STAGING: A SCOPING REVIEW

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ABSTRACT

Introduction: The outbreak of novel coronavirus (SARS-CoV-2) in Wuhan, China, occurred in December 2019. The World Health Organisation (WHO) named it coronavirus disease-19 (COVID-19). Common clinical signs of COVID-19 include fever, coughing, shortness of breath, myalgia, and exhaustion. While the RT-PCR test remains the gold standard for diagnosis, false-negative results are prevalent. Chest radiography and CT scans, which primarily focus on lung abnormalities, can complement RT-PCR in diagnosing and monitoring the disease. This study explores the roles of MRI, PET-CT, and SPECT-CT as diagnostic imaging modalities for COVID-19, aiming to improve clinical diagnosis and patient management. **Methods:** A scoping review was undertaken by systematically searching a number of databases, including PubMed, Scopus, and Google Scholar. The search was done using relevant keywords such as COVID-19, MRI, hybrid imaging, PET-CT, SPECT-CT, progression, and staging. Our study primarily focused on articles that emphasise the significance of imaging techniques for assessing COVID-19 disease progression and staging, following specific inclusion and exclusion criteria. **Results:** Fourteen relevant articles were reviewed. Medical imaging modalities, such as MRI, and hybrid techniques like PET-CT and SPECT-CT can effectively identify abnormalities caused by COVID-19 in patient images. However, they may not always distinguish overlapping pneumonia specifically associated with COVID-19. **Conclusion:** In conclusion, MRI, PET-CT, and SPECT-CT can provide complementary diagnostic images for understanding the progression and staging of COVID-19. These imaging modalities enhance patient management and follow-up, offering valuable insights into the disease's impact on the body.

Keywords: COVID-19, MRI, Hybrid Imaging, PET-CT, SPECT-CT, Progression, Staging

INTRODUCTION

In late 2019, the world received a shocking alert from the Health Ministry of China about a mysterious outbreak of pneumonia cases in the city of Wuhan, located in the Hubei District of Central China. This challenging health crisis initially unfolded at the Hua Nan Seafood and wet animal wholesale market, but what made it even more puzzling was the fact that it began affecting locals who had no direct exposure to this market (Harapan et al., 2020). At the start of the year 2020, the market was promptly closed in response to the unfolding situation. A mere week later, scientists identified the causative agent as a novel betacoronavirus, closely related to the infamous SARS-CoV and a group of bat-borne SARS-like coronaviruses (Mackenzie & Smith, 2020). Initially dubbed "novel coronavirus" (nCOV), it was subsequently officially named coronavirus disease 2019 (COVID-19) by the World Health Organisation

(WHO). It is also commonly referred to as SARS-CoV-2, which is derived from severe acute respiratory syndrome coronavirus 2 (Singhal, 2020).

The COVID-19 outbreak rapidly escalated, causing significant loss of life and wreaking havoc on economies worldwide. The first deaths occurred in China, where the China National Health Commission meticulously recorded them up until January 22, 2020 (Rothan & Byrareddy, 2020). However, this deadly virus soon transcended borders, spreading to countries like Italy, European nations, and the United States, where the number of confirmed cases surged relentlessly (Pascarella et al., 2020). As of May 10, 2023, the World Health Organisation (WHO) has reported a staggering 756,903,278 confirmed cases of COVID-19, with 6,927,378 tragic fatalities worldwide (World Health Organisation, 2023) as shown in Table 1.

Table 1. Confirmed COVID-19 cases on the globe by 10 May 2023 (WHO 2023)

Region	**Confirmed Cases**
Europe	276,136,217
Western Pacific	203,172,588
Americas	192,581,201
South-East Asia	61,120,704
Eastern Mediterranean	23,364,240
Africa	9,527,564

Initial local health concern soon escalated into a global pandemic, with COVID-19 reaching 213 nations and independent territories around the world (Chamola et al., 2020) as shown in Table 1. The rapid spread of this highly contagious and transmissible disease led the WHO to declare COVID-19 a pandemic, a declaration that has reshaped the course of modern history and continues to pose profound challenges to the global community (Pascarella et al., 2020).

The COVID-19 pandemic has posed unprecedented challenges to healthcare institutions on a global scale. The sheer magnitude of cases overwhelmed testing capacities, primarily relying on polymerase chain reaction (PCR) tests, which are both time-consuming and expensive. Moreover, the prevalence of both false positive and false negative outcomes in polymerase chain reaction (PCR) testing is widespread, hence necessitating the exploration of alternate diagnostic approaches. A review study conducted by Nor Fitri, and Sayed (2023) and reported that the diagnostic accuracy of plain X-ray, CT, and ultrasound modalities can vary depending on factors such as the stage of the disease, the expertise of the healthcare provider, and the specific equipment and protocols used. Additionally, the sensitivity of these modalities may change over time as new research and guidelines emerge. Moreover, alternate advanced imaging technologies such as MRI, PET-CT, and SPECT-CT may offer further supplementary insights into the pathophysiology and severity of COVID-19-related illnesses. In addition, the implementation of alternate strategies in situations where polymerase chain reaction (PCR) testing is inadequate or inaccessible can play a significant role in a complete understanding of COVID-19 and its progression and management.

Therefore, this review study explores the significance of advanced diagnostic imaging techniques, such as MRI, PET-CT, and SPECT-CT, in the diagnosis, assessment, and management of COVID-19.

METHODOLOGY

In this research endeavour, a thorough article selection process was conducted across various online databases, such as PubMed, Scopus, and Google Scholar. The focus was on the COVID-19 pandemic and its relationship with medical imaging techniques like MRI, PET-CT, and SPECT-CT. Boolean queries, including "AND," "OR," and "NOT," were employed to refine search results effectively.

The keywords used in the search included COVID-19, MRI, hybrid imaging, PET-CT, SPECT-CT, progression, and staging. Only English-language, full-text articles published between 2019 and 2023 were considered for inclusion to ensure that the sources used in the study were both relevant and up-to-date. Moreover, the articles should be relevant to the COVID-19 pandemic and medical diagnostic imaging techniques like MRI, PET-CT, and SPECT-CT.

Data extraction was meticulously carried out in accordance with the inclusion criteria, with Microsoft Excel serving as the organising tool. The extracted data encompassed details such as author(s), year of publication, title, and findings from the article.

Furthermore, we adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis methodology throughout the review process to ensure transparency and rigour in the selection of articles for the study.

RESULTS

In this review we employed PubMed, Scopus, and Google Scholar, databases to search for relevant online articles. The initial search yielded a total of 103 relevant studies/articles. Microsoft Excel was then used to manage and identify duplicate materials, resulting in the removal of 10 duplicate items. Following this, the remaining 93 articles underwent a thorough screening process based on their titles and abstracts, with a focus on their relevance to the research topic. After this screening, 37 articles remained for further review. The 37 articles were subjected to additional scrutiny, which involved a more detailed assessment of their content. During this phase, 23 articles were excluded due to insufficient justification, a lack of essential information, or the absence of full-text articles. Consequently, only 14 articles were deemed suitable for inclusion in the research, shown in Table 2.

Table 2. Summary of articles included in this study

Title	Imaging modalities	Roles in Managing COVID-19	References
A Comprehensive Survey of COVID-19 Detection Using Medical Images	MRI	Resolves characteristic features Alternative for imaging high-risk group	Mohammad et al., 2023
Characterization of COVID-19-Related Lung Involvement in Patients Undergoing Magnetic Resonance T1 and T2 Mapping Imaging: A Pilot Study	MRI	Resolves characteristic features	Camastra et al., 2022
Imaging of COVID-19: CT, MRI, and PET	MRI PET-CT	Resolves characteristic features Alternative for imaging high-risk group	Fields et al., 2021

		Monitoring disease progression	
Magnetic resonance imaging features of coronavirus disease 2019 (COVID-19) pneumonia: The first preliminary case series	MRI	Resolves characteristic features Monitoring disease progress	Torkian et al., 2021
Chest MRI of patients with COVID-19	MRI	Resolves characteristic features Alternative for imaging high-risk group	Vasilev et al., 2021
The Clinical Utility of Molecular Imaging in COVID-19: An Update	PET-CT	Resolves characteristic features Progression of disease	Elsakka et al., 2023
FDG PET/CT imaging features and clinical utility in COVID-19	PET-CT	Assess pulmonary disease Staging of the disease	Yeh et al., 2021
FDG-PET/CT imaging during the Covid-19 emergency: a southern Italian perspective	PET-CT	Assess the extent of the disease Staging of disease	Maurea et al., 2020
FDG-PET/CT of COVID-19 and Other Lung Infections	PET-CT	Malignancy evaluation and staging Resolves characteristic features	Eibschutz et al., 2022
Diagnostic Value of Imaging Modalities for COVID-19: Scoping Review	PET-CT	Assessing progression and staging of disease Assessing and monitoring of lung disease	Aljondi & Alghamdi, 2020
A comprehensive review of imaging findings in COVID-19 - status in early 2021	SPECT-CT	Assessing the progression and staging of the disease Assessing and monitoring of lung disease Resolves characteristic features	Afshar-Oromieh et al., 2021
Lung Scientigraphy for Pulmonary Embolism Diagnosis in COVID-19	SPECT-CT	Assessing and monitoring of	Roux et al., 2021

Patients: A Multicenter Study		lung disease Assess pulmonary changes	
Ventilation/perfusion SPECT/CT findings in different lung lesions associated with COVID-19: a case series	SPECT-CT	Resolves characteristic features Assessing the progression and staging of the disease Assessing and monitoring of lung disease	Cobes et al., 2020
Investigation of perfusion defects by Q-SPECT/CT in patients with mild-to-moderate course of COVID-19 and low clinical probability for pulmonary embolism.	SPECT-CT	Assessing and monitoring of lung disease	Ozturk et al., 2021

Effectiveness of Magnetic Resonance Imaging in Detecting COVID-19

The investigated literature reveals that MRI demonstrates significant promise as a diagnostic tool for COVID-19, with a high level of accuracy in detecting associated lung abnormalities. Fields et al. (2021) found MRI to have a sensitivity of 91.7%, a specificity of 100%, a positive predictive value of 100%, and a negative predictive value of 95.2%. Various MRI sequences, including T2-weighted sequences like half-Fourier acquisition single-shot turbo spin echo (HASTE), turbo spin echo (TSE), fast imaging with steady-state precession (FISP), and turbo inversion recovery magnitude (TIRM), enhance the precision of COVID-19 lung abnormality identification. The T2-weighted TSE-TIRM sequence is particularly effective in highlighting lesions associated with oedema, a common feature of COVID-19 disease. MRI can distinguish between subacute bleeding-induced changes in signal intensity and consolidation due to fibrous structures. Additionally, MRI is shown to be comparable to CT scans in detecting ground-glass opacities (GGOs) and consolidative lesions associated with COVID-19.

Despite its potential, MRI has limitations in COVID-19 diagnosis, including susceptibility to signal loss due to physiological factors (respiration and heartbeat), lower spatial resolution, and longer examination times. These factors may restrict its practicality in certain clinical settings (particularly in emergency). Further research and validation are needed to determine the optimal role of MRI in COVID-19 diagnosis and management.

PET-CT in Diagnosing and Monitoring of COVID-19

The primary radiotracer used in FDG PET-CT is 18F-labelled fluorodeoxyglucose (18F-FDG), which effectively highlights metabolic activity in inflamed areas. PET-CT in diagnosing and monitoring COVID-19 pneumonia yields several significant results and implications; like PET-CT, are better than traditional imaging methods for figuring out how COVID-19 is getting worse, how well treatment is working, and what the prognosis is (Elsakka et al., 2023).

Furthermore, PET-CT can show the immune response of the host to COVID-19 by showing the presence of inflammatory cytokines, alveolar macrophages, and neutrophils in the lungs (Yeh et al., 2021). This can aid in identifying COVID-19 and assessing its severity. Moreover, PET-CT demonstrates the potential to detect COVID-19 in asymptomatic individuals, even before symptoms appear (Eibschutz et al., 2022). This early detection could lead to timely interventions and reduced virus transmission.

PET-CT is highly sensitive in detecting COVID-19-related changes, it may lack specificity, potentially leading to false-positive results (Fields et al., 2021; Elsakka et al., 2023). Caution is needed when interpreting findings, especially in patients with underlying health conditions. PET-CT has clinical implications for understanding COVID-19 disease trajectories and evaluating treatments for patients with persistent respiratory symptoms. It can uncover findings that standard tests might miss, guiding more targeted treatments (Eibschutz et al., 2022). In addition, clinical decisions regarding the use of PET-CT in COVID-19 diagnosis and monitoring should prioritise patient safety and effectiveness, considering both the benefits of early detection and the limitations in specificity.

PET-CT holds promise as a valuable tool in diagnosing and monitoring COVID-19 pneumonia. It provides unique insights into disease progression and the immunological response. However, its lower specificity requires careful consideration when interpreting results. The results underscore the need for additional research and clinical validation to fully comprehend the role of PET-CT in COVID-19 management, especially across different patient populations and disease stages. Therefore, continued research and clinical validation are essential to maximising its potential in patient care.

Significance of SPECT-CT in diagnosing COVID-19

COVID-19 patients often experience coagulopathy, characterised by microthrombosis and venous thromboembolism. Studies by Cobes et al. (2020) and Roux et al. (2021) support this finding. Pulmonary embolism (PE) occurs in COVID-19 patients, predominantly in peripheral lung regions, suggesting microvascular thrombus formation due to vascular injury, different from traditional PE. Lung ventilation-perfusion (V/Q) scintigraphy, as described by Roux et al. (2021), is a valuable tool for diagnosing PE in COVID-19 patients, relying on wedge-shaped perfusion mismatch defects. Cobes et al. (2020) found that COVID-19-related lung lesions did not change the V/Q single-photon emission computed tomography (SPECT) patterns in COVID-19 cases. However, V/Q SPECT-CT remains reliable for identifying thromboembolic disorders in these patients. In COVID-19 pneumonia patients, Afshar-Oromieh et al. (2021) saw different ventilation SPECT patterns even though pulmonary parenchymal perfusion was the same. This highlights the complexity of COVID-19 lung involvement and the need for advanced imaging techniques.

In summary, the literature provides insights into COVID-19's multi-organ impact, with a focus on coagulopathy and PE. It underscores the importance of V/Q scintigraphy and SPECT-CT in diagnosing PE in COVID-19 patients and highlights the unique patterns seen in these individuals. These findings contribute to our evolving understanding of COVID-19 and can aid clinicians in early thromboembolic complication detection and management.

DISCUSSION

Role of MRI, PET-CT, and SPECT-CT in Detecting, Progression, and Staging of COVID-19

Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging (MRI) is a non-invasive diagnostic tool known for creating detailed images of the human body without using harmful radiation. However, it is underutilised in diagnosing COVID-19 compared to alternatives like CT scans and lung ultrasound due to its longer examination time and higher cost. Instead of that the literature suggests that MRI can be a valuable tool for diagnosing COVID-19 pneumonia. Studies mentioned, such as Fields et al. (2021) and Muhammad et al. (2023), indicate that MRI shows a high sensitivity, specificity, positive predictive value, and negative predictive value when compared to CT scans. These findings suggest that MRI can accurately identify pulmonary lesions associated with COVID-19.

The various MRI sequences, such as T2-weighted sequences like HASTE, TSE, FISP, and TIRM, which are effective in identifying lung infiltrations. Additionally, it mentions that the T2-weighted TSE-TIRM sequence is particularly useful for detecting oedema, which is a common feature of COVID-19

pneumonia. This information suggests that specific MRI sequences can enhance the precision of the COVID-19 diagnosis. MRI can distinguish between different types of lesions in COVID-19 pneumonia. For example, it can differentiate consolidation linked to fibrous structures due to the relatively "short" T2 component. This ability to differentiate lesions may aid in understanding the stage and severity of the disease.

Furthermore, ground-glass opacities (GGOs) and consolidative lesions are detectable with MRI in a manner similar to CT, according to Ates et al. (cited by Fields et al., 2020). This finding is significant because GGOs are a common radiological feature of COVID-19 pneumonia. Additionally, the literature suggests that MRI findings are generally in agreement with the positions of consolidations seen on CT scan images. This concordance between MRI and CT findings further supports the use of MRI in assessing COVID-19-related lung abnormalities.

The literature acknowledges several limitations of using MRI for COVID-19 diagnosis. These include signal deprivation due to physiological factors like respiration and heartbeat, lower spatial resolution, and longer examination times. These limitations need to be considered when deciding whether to use MRI for COVID-19 assessment. Despite the challenges posed by signal deprivation, time and cost, MRI has the potential to play a significant role in diagnosing and understanding COVID-19 susceptibility in patients with cardiac conditions. Its ability to provide high-quality images can help healthcare professionals better visualise and comprehend the anatomical and functional performance of various organs affected by COVID-19. This is particularly crucial for patients with pre-existing cardiac conditions who are at higher risk for severe complications (Di Dong et al., 2021).

There are ample opportunities for research in this area, including assessing various diagnostic imaging techniques and thoroughly examining organ impairment and disease mechanisms in COVID-19 patients. Such research can lead to improved diagnostic and treatment strategies for individuals with cardiac conditions, helping to reduce the risk of severe COVID-19 complications.

In conclusion, the discussed studies and findings suggest that MRI can be a valuable imaging modality for diagnosing and assessing COVID-19. It offers high sensitivity and specificity and can provide detailed information about pulmonary lesions and their characteristics. However, it is essential to acknowledge its limitations and consider the specific clinical context when choosing between MRI and other imaging techniques like CT for COVID-19 diagnosis and evaluation.

Positron Emission Tomography-Computed Tomography (PET-CT)

Positron emission tomography-computed tomography (PET-CT) with 18F-2-fluoro-2-deoxy-D-glucose (FDG) has become a highly sensitive diagnostic tool for early detection and monitoring of infections, and inflammations. Eibschutz et al. conducted a study in 2022 that highlighted the potential of PET-CT as a primary modality for diagnosing non-cancerous diseases, particularly lung infections. In addition, the literature emphasises the use of 18F-FDG as the commonly used radiotracer in PET-CT, which reveals metabolic activity in inflamed areas.

Elsakka et al., 2023 stated that PET-CT, is superior to conventional imaging for diagnosing illness progression, treatment surveillance, and prognosis in individuals with COVID-19. Further, the immunological host response to COVID-19, such as the release of inflammatory cytokines and the accumulation of alveolar macrophages and neutrophils in the lungs, can be seen through FDG uptake (Yeh et al., 2021). This indicates that FDG PET-CT may help in identifying COVID-19.

Research published by (Fields et al., 2021; Elsakka et al., 2023) reports increased FDG uptake in the lungs of individuals with COVID-19, with maximum standardised uptake (SUVmax) values ranging from 4.6 to 12.2. The literature suggests that FDG uptake tends to increase as the disease progresses but decreases with virus elimination and the emergence of immunity.

Moreover, PET-CT can detect ground-glass opacities (GGOs) with enhanced metabolic activity in a peripheral, basilar, and posterior dominant pattern, often overlapping with consolidation (Eibschutz et al., 2022). Further, the study has reported the utility of PET-CT in detecting COVID-19 in asymptomatic individuals, even before the onset of symptoms. PET-CT showed higher SUVmax values in the lungs of infected individuals compared to controlled subjects (Fields et al., 2021; Eibschutz et al., 2022; Elsakka et al., 2023).

The literature acknowledges that while 18F-FDG PET-CT is very sensitive in evaluating COVID-19, it may have poor specificity. This suggests that it can detect COVID-19-related changes but may not always distinguish them from other conditions (Fields et al., 2021; Elsakka et al., 2023).

The articles mention that PET-CT can help understand the disease trajectory of COVID-19 and evaluate treatments for individuals with persistent respiratory symptoms. It also suggests that staging PET-CT scans may reveal unintentional findings that standard test scans might miss, potentially leading to further treatment (Eibschutz et al., 2022).

In summary, the published work highlights the potential of 18F-FDG PET-CT as a sensitive imaging technique for identifying and monitoring COVID-19 pneumonia, particularly in its early stages. However, it also acknowledges the need for caution due to the technique's poor specificity, especially in populations at risk, like oncology patients. Further research and clinical evaluation are necessary to fully understand the clinical utility of FDG PET-CT in managing COVID-19.

Single Photon Emission Computed Tomography-Computed Tomography (SPECT-CT)

The COVID-19 pandemic has presented numerous challenges to healthcare professionals, with a growing body of evidence highlighting the virus's multi-organ impact with a significant focus on coagulopathy. It indicates that this coagulopathy is a prominent feature of the SARS-CoV-2 disorder. Coagulation abnormalities are in the form of micro thrombosis and venous thromboembolism. To address the diagnostic challenges posed by PE in COVID-19 patients, alternative imaging techniques have been explored, especially when contrast-enhanced CT scans are not feasible, such as in cases of renal failure. Studies carried out by Cobes et al. (2020), Roux et al. (2021), and Afshar-Oromieh et al. (2021) support this conclusion.

A promising approach is ventilation/perfusion single photon emission computed tomography (V/Q-SPECT), with a particular emphasis on the perfusion (Q) component. This method helps minimise the risk of COVID-19 transmission and offers an alternative to low-dose Q-SPECT-CT. Focusing on perfusion, lung scintigraphy allows for a full analysis of pulmonary abnormalities, such as holes in the parenchyma, pleura, and chest lining. It works well with CT scans and other imaging methods. In patients with minimal clinical suspicion for embolism, perfusion scintigraphy has proven to be a reliable method for excluding it. In addition, the lung ventilation-perfusion (V/Q) scintigraphy describes the characteristic features of PE, such as wedged-shaped perfusion mismatch defects, which are perfusion abnormalities with normal ventilation. It is important to note that the majority of PEs brought on by COVID-19 occur in peripheral areas. This suggests that thrombus formation takes place at micro vascular levels due to vascular injury, rather than migrating to the pulmonary vascular area. Ozturk et al. (2021) are referenced to support this observation. Cobes et al. (2020) reported on five cases of COVID-19 individuals with distinct V/Q SPECT-CT patterns and features. Notably, they discovered that COVID-19 pulmonary lesions had no impact on the identification of thromboembolic disorders.

Regions affected by COVID-19, especially during the initial phase with ground glass opacities, often exhibit maintained perfusion with minimal or no reduction in ventilation. However, as the disease progresses, alveolar fillings and parenchymal anomalies can lead to impaired perfusion, with perfusion anomalies matching the ventilation. This observation is attributed to Cobes et al. (2020). Afshar-Oromieh et al. found in 2021 that COVID-19 pneumonia patients with ground glass infiltrates can show heterogeneous ventilation SPECT patterns with maintained perfusion in the pulmonary parenchyma.

The literature suggests that perfusion patterns may vary among patients, reflecting concurrent CT infiltrate findings.

The findings of the study underscore the significant impact of coagulopathy in COVID-19 patients, leading to micro thrombosis and venous thromboembolism, particularly pulmonary embolism. It cites studies to support findings related to the detection of PE and the characteristics of ventilation-perfusion abnormalities in COVID-19 pneumonia. Understanding these aspects is crucial for managing and treating COVID-19 patients, especially those at risk of thromboembolic complications.

Extensive research has validated the diagnostic accuracy and treatment efficacy of lung scintigraphy-based approaches. Large-scale studies show that lung scintigraphy is a good way to find out if someone has a pulmonary embolism. It does this mainly by finding perfusion problems or defects along with normal ventilation.

Lung scintigraphy, with a focus on perfusion, is a valuable diagnostic tool in the context of the COVID-19 pandemic, where pulmonary embolism has emerged as a critical concern. This approach aids in early and accurate detection while reducing the risk of COVID-19 transmission during imaging procedures. (Afshar-Oromieh et al., 2021; Roux et al., 2021; Ozturk et al., 2021; Cobes et al., 2020) show how important lung scintigraphy-based approaches are for treating COVID-19 patients who might have a pulmonary embolism.

This review study looked at how important diagnostic imaging techniques like magnetic resonance imaging (MRI), positron emission tomography-computed tomography (PET-CT), and single photon emission computed tomography-computed tomography (SPECT-CT) are in diagnosing and treating coronavirus disease 2019 (COVID-19). In our current global landscape, where the prevalence of this disease continues to challenge healthcare systems, it is crucial to continually explore and harness the potential of medical imaging modalities to enhance clinical strategies. Traditionally, chest CT scans have been the standard imaging method for managing COVID-19 patients since the inception of the pandemic. However, our investigation, alongside previous studies, has illuminated the comparable capabilities of chest MRI, PET-CT, and SPECT-CT in detecting the abnormalities associated with COVID-19. While these modalities are not considered primary diagnostic tools for identifying and distinguishing pulmonary COVID-19, their utility in the context of the disease is noteworthy. Our findings highlight that MRI exhibits similar sensitivity to CT scans in detecting and localising COVID-19, making it a viable alternative, particularly for high-risk individuals or cases where CT is contraindicated. Meanwhile, PET-CT, despite its limitations in specificity, offers high sensitivity for pinpointing COVID-19-related abnormalities and tracking disease progression. Though there is currently limited evidence and research specifically focused on identifying COVID-19 pneumonia through SPECT-CT images, these images have shown promise in detecting abnormalities through the observation of perfusion and ventilation defects. While these modalities may not be firmly established for COVID-19 patients, their ability to identify disease-related abnormalities and provide supplementary insights into disease progression and staging holds significant potential for improving patient management and prognosis. In essence, as the medical community continues to deal with the multifaceted challenges posed by COVID-19, the integration of MRI, PET-CT, and SPECT-CT into diagnostic and monitoring protocols presents a promising avenue. These techniques, although not the primary choices, can play vital roles in the wide-ranging care and understanding of COVID-19 patients, ultimately contributing to more effective strategies for diagnosis, management, and treatment of this global health crisis. Further research and clinical validation are essential to harnessing their full potential in the fight against COVID-19.

CONCLUSION

This comprehensive study explored the valuable roles of advanced diagnostic imaging techniques such as MRI, PET-CT, and SPECT-CT in diagnosing and managing COVID-19. Traditionally, chest CT scans have been the standard, but this review reveals that MRI can provide similar sensitivity to CT scans,

making it a viable alternative, especially for high-risk individuals or cases where CT is not suitable. PET-CT, despite limitations in specificity, offers high sensitivity for identifying COVID-19-related abnormalities and tracking disease progression. Additionally, SPECT-CT shows promise in detecting abnormalities related to COVID-19, particularly in observing perfusion and ventilation defects. These modalities may not be primary diagnostic tools, but they offer supplementary insights into disease progression and patient management. As the medical community continues to address the challenges of COVID-19, integrating MRI, PET-CT, and SPECT-CT into diagnostic and monitoring protocols can contribute to more effective strategies for diagnosis, treatment, and management of this global health issue, although further research and clinical validation are essential to fully harnessing their potential.

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