Volume 22, No 2 | International Journal of Radiation Research, April 2024

The role of multimodal medical imaging in the diagnosis and differential diagnosis of myocarditis

W. Wang[1], D. Feng[1], Q. Song[1], W. Sun[1], D. Zhang[1], M. Li[1], K. Li[1], H. Chen[2*], F. Li[*]

[1]*Heilongjiang University of Chinese Medicine, Heilongjiang, China*
[2]*Department of Pediatrics, First Affiliated Hospital of Heilongjiang University of Traditional Chinese Medicine, Heilongjiang, China*

► ***Review article***

***Corresponding author:**
Hong Chen & Fei Li,
E-mail:
18845058624@163.com

Received: November 2023
Final revised: January 2024
Accepted: January 2024

Int. J. Radiat. Res., April 2024; 22(2): 243-250

DOI: 10.61186/ijrr.22.2.243

Keywords: *Multimodal medical imaging, differential diagnosis, myocarditis, cardiac function, imaging technology.*

ABSTRACT

Background: Multimodal medical imaging plays a key role in the diagnosis and differential diagnosis of myocarditis, enabling a comprehensive assessment of cardiac structure and function. ***Materials and Methods:*** We used multimodal medical imaging technology to diagnose and differential diagnose patients with myocarditis, and analyzed the patient data in detail. ***Results:*** Multimodal medical imaging techniques provide a wealth of information to help distinguish myocarditis from other heart diseases. ***Conclusion:*** Multimodal medical imaging is of great value in the diagnosis and differential diagnosis of myocarditis, but there are still some challenges and limitations in its application.

INTRODUCTION

Myocarditis is an inflammatory condition affecting the myocardium, primarily instigated by infectious agents. Notably, viral pathogens such as Coxsackie virus, Echovirus, and influenza virus are frequently implicated in its etiology [(1)]. The impact of myocarditis extends beyond the heart's function, as it can lead to serious complications and even death. Therefore, a comprehensive understanding and analysis of myocarditis is crucial for the prevention, diagnosis, and treatment of this disease. The pathogenesis of myocarditis primarily involves the direct invasion of particles into cardiomyocytes after infection, resulting in their damage and death [(2)]. Additionally, the virus can trigger an immune response that damages heart muscle cells, leading to the development of myocarditis [(3)]. While myocarditis can affect individuals of any age, it is most prevalent in young adults and children. Furthermore, the incidence of myocarditis significantly increases during seasonal and climate changes [(4)].

This common cardiovascular disease can result in impaired myocardial function, arrhythmia, heart failure, and even death. Effective prevention and treatment of myocarditis not only alleviate patient symptoms but also reduce the risk of complications and mortality. Outbreaks and epidemics of myocarditis can have a profound impact on public health, necessitating the implementation of effective prevention and control measures. Multimodal medical imaging technology, encompassing echocardiography, cardiac magnetic resonance imaging (MRI), positron emission tomography (PET), and other imaging methods, enables a comprehensive and detailed understanding of a patient's condition [(5)].

In the diagnosis and differential diagnosis of myocarditis, these techniques play a crucial role in providing valuable information on the degree and severity of myocardial inflammation, as well as in distinguishing myocarditis from other cardiac diseases [(6)]. One of the primary advantages of multimodal medical imaging in the diagnosis of myocarditis lies in its capability to offer a comprehensive assessment of cardiac structure and function [(7)]. For instance, echocardiograms offer real-time images of heart chambers, valves, and blood flow, facilitating the assessment of heart function and the detection of abnormalities. In contrast, cardiac MRI can provide detailed images of the heart, including information on myocardial inflammation, edema, and fibrosis.

PET imaging, on the other hand, can offer myocardial metabolic and perfusion information to

[DOI: 10.61186/ijrr.22.2.243]

aid in the assessment of myocardial inflammation and damage [8]. Moreover, multimodal medical imaging can aid in distinguishing myocarditis from other heart conditions that may present similar symptoms. For example, cardiac MRI can help differentiate myocarditis from other forms of myocardium inflammation, such as autoimmune myocarditis or myocardial sarcoidosis, by providing information on the pattern and distribution of myocardium inflammation [9]. Similarly, PET imaging can assist in distinguishing between myocarditis and ischemic heart disease by offering myocardial perfusion and metabolic information.

Additionally, multimodal medical imaging technology can play a vital role in monitoring the treatment response of patients with myocarditis. By providing detailed information on myocardial inflammation, function, and perfusion, multimodal medical imaging can help clinicians assess the effectiveness of treatments and make informed decisions about patient management. The application of multimodal medical imaging technology in the diagnosis and differential diagnosis of myocarditis offers the advantages of comprehensive evaluation of cardiac structure and function, differentiation from other heart diseases, and monitoring of treatment effect [10]. As technology continues to advance, the role of multimodal medical imaging in the diagnosis and treatment of myocarditis is likely to become more important in the future.

Echocardiography is a non-invasive imaging technique that uses sound waves to produce images of the heart. It is often used for initial evaluation in patients with suspected myocarditis because it can provide information about the size and function of the heart and whether there is an abnormal structure or fluid buildup [11]. Cardiac MRI is a more advanced imaging technique that provides detailed images of the heart's structure and function. It is particularly useful in the diagnosis of myocarditis because it can provide information on the extent of myocardial damage, the presence of inflammation, and any associated complications.

PET imaging is a highly sensitive imaging technique that can detect metabolic changes in the heart. It is particularly useful in the diagnosis of myocarditis because it can provide information about the presence of inflammation and the extent of damage to the heart muscle, even in the absence of structural abnormalities. In addition to improving diagnostic accuracy, the use of multimodal imaging in the diagnosis and differential diagnosis of myocarditis can also help clinicians identify patients who may benefit from more aggressive treatment options, such as immunosuppressive therapy or ventricular assist devices. Overall, the use of multimodal medical imaging techniques in the diagnosis and differential diagnosis of myocarditis is an important step toward more accurate and effective management of this potentially life-threatening disease.

The novel aspect of this study is that it focuses on advances in the diagnosis and differential diagnosis of myocarditis based on multimodal medical imaging technology, which has not been studied in depth before. Our aim is to conduct a comprehensive analysis of the diagnosis and differential diagnosis of myocarditis with multimodal medical imaging techniques and to draw meaningful conclusions from our findings. The use of multimodal medical imaging techniques in the diagnosis and differential diagnosis of myocarditis is an important step toward more accurate and effective management of this potentially life-threatening condition.

The clinical presentation of myocarditis can vary greatly depending on the severity of the inflammation and the specific virus causing the infection. Symptoms of myocarditis can range from mild to severe and include chest pain, shortness of breath, fatigue, swelling of the legs or ankles, heart palpitations, irregular heartbeat, cardiac arrest, and even death [12]. The onset of symptoms is usually sudden and may occur several weeks after the initial infection. The diagnostic criteria for myocarditis are based on a combination of clinical symptoms, blood tests, and imaging. Blood tests are used to determine the presence of specific antibodies against the virus, elevated heart enzyme levels, and abnormal white blood cell counts.

Imaging studies such as echocardiography and magnetic resonance imaging (MRI) can reveal structural changes in the heart muscle and evidence of inflammation. Electrocardiogram (ECG) is also an important tool for diagnosing myocarditis. This test can detect abnormalities in the electrical activity of the heart, including changes in the rhythm and rate of the heartbeat. An abnormal ECG indicates inflammation of the heart muscle. In severe cases of myocarditis, a tissue biopsy may be required to confirm the diagnosis. A small sample of heart tissue is surgically removed and examined under a microscope for evidence of inflammation and damage to cardiomyocytes.

Multimodal medical imaging technology

Diagnosis and differential diagnosis of myocarditis by X-ray imaging technology

X-ray imaging technology serves as a commonly employed method for diagnosing and differentiating myocarditis [13]. This technique enables the observation of the heart's size, shape, contour, and edges, as well as the presence of pericardial effusion. Individuals with myocarditis may exhibit either an enlarged or normal-sized heart. By examining the size and shape of the heart, X-ray imaging technology aids in assessing the heart's structure and function [14]. Additionally, patients with myocarditis may experience pericardial effusion. X-ray imaging

[DOI: 10.61186/ijrr.22.2.243]

techniques can determine the presence of pericardial effusion by assessing the normalcy of the heart shadow's outline and edges.

Moreover, X-ray imaging technology provides valuable insights into other organs, such as lung infections and pleural effusion, thereby facilitating a comprehensive understanding of the patient's overall condition [15].Given that the symptoms of myocarditis resemble those of other cardiovascular diseases like myocardial infarction and heart failure, X-ray imaging technology offers additional information regarding the heart's structure and function, aiding in the differential diagnosis. Patients with myocarditis often present symptoms such as lung infections and pleural effusion. X-ray imaging technology allows for the observation of lung conditions, enabling differentiation from other lung diseases.

In summary, X-ray imaging technology is a valuable tool for diagnosing and differentiating myocarditis [16]. It provides information about the heart's structure, function, and the presence of pericardial effusion. Additionally, it assists in assessing lung conditions, distinguishing myocarditis from other diseases.

Diagnosis and differential diagnosis of myocarditis by CT imaging

Electronic computed tomography (CT) imaging technology holds significant value in the diagnosis and differential diagnosis of myocarditis [17]. By observing the structure and function of the heart, detecting pericardial effusion, and determining the cause and condition, doctors can develop more accurate treatment plans. Additionally, CT imaging allows for real-time monitoring of disease progression, enabling timely adjustments to treatment plans and evaluation of treatment effectiveness. CT imaging provides crucial information about the heart's structure and function, aiding doctors in evaluating myocardial damage and disease assessment.

CT imaging technology offers detailed visualization of the heart's structure and function, encompassing the myocardium, pericardium, and heart cavities. By observing these structural changes, doctors can assess the extent of heart muscle damage and determine the condition [18]. Furthermore, CT imaging technology detects the presence of pericardial effusion, providing valuable insights into its extent and location. This information is vital for the diagnosis and evaluation of myocarditis. By observing changes in the heart's structure and function, CT imaging technology assists doctors in determining the cause and condition of myocarditis. For instance, narrowing and blockage of the coronary arteries can indicate the presence of coronary arteritis.

Considering that the symptoms of myocarditis resemble those of other cardiovascular diseases like myocardial infarction and heart failure, CT imaging technology offers additional information about the heart's structure and function, facilitating differential diagnosis [19]. For example, Coronary CT angiography (CCTA) enables the observation of coronary artery narrowing and blockage, aiding in the distinction of coronary heart disease. Moreover, patients with myocarditis often exhibit symptoms such as lung infections and pleural effusion. CT imaging technology allows for the assessment of lung conditions, distinguishing myocarditis from other lung diseases. Regular CT imaging can monitor changes in the condition of patients with myocarditis, such as myocardial damage repair and pericardial effusion. This enables doctors to evaluate treatment effectiveness and make necessary adjustments to treatment plans.

In summary, electronic CT imaging technology plays a crucial role in the diagnosis and differential diagnosis of myocarditis [20]. It provides comprehensive information about the heart's structure, function, and the presence of pericardial effusion. Moreover, CT imaging facilitates the evaluation of myocardial damage, determination of disease cause and condition, and aids in differential diagnosis from other cardiovascular diseases. Regular CT imaging allows for monitoring disease progression and treatment effectiveness, enabling timely adjustments to treatment plans.

Diagnosis and differential diagnosis of myocarditis by MRI imaging

Magnetic resonance imaging (MRI) technology holds significant value in the diagnosis and differential diagnosis of myocarditis [21]. By revealing heart muscle damage and inflammation, evaluating heart function, offering insights into systemic inflammation, and tracking changes in the condition, it enables physicians to comprehensively comprehend the patient's status and etiology, facilitating the development of more precise treatment strategies. Simultaneously, by monitoring disease progression, it allows for timely adjustments to treatment plans and evaluation of treatment efficacy.

MRI imaging technology plays a crucial role in evaluating cardiac function, encompassing ventricular systolic and diastolic function [22]. Identification of aberrations in heart function aids in comprehending the impact of myocarditis on the heart. Additionally, MRI imaging technology can furnish insights into systemic inflammation, enabling physicians to ascertain the presence of inflammation in other organs. This comprehensive understanding of the patient's condition and its underlying causes is pivotal. Given the symptomatic similarities between myocarditis and other cardiovascular diseases such as myocardial infarction and heart failure, MRI imaging technology can provide valuable information about cardiac structure and function, aiding in differential diagnosis [23]. For instance, assessment of heart muscle fibrosis and necrosis can facilitate differentiation from myocardial infarction. Furthermore, by examining heart muscle damage and inflammation, MRI imaging technology can assist in determining the etiology and status of myocarditis. For instance, evaluation of cardiomyocyte edema and fibrosis can aid in identifying autoimmune myocarditis. Regular MRI imaging can monitor changes in the condition of myocarditis patients, including myocardial damage repair and cardiac function improvement [24]. This facilitates the evaluation of treatment efficacy and the adjustment of treatment plans.

Diagnosis and differential diagnosis of myocarditis by ultrasonography

Ultrasound imaging technology has important application value in the diagnosis and differential diagnosis of myocarditis [25]. By observing the structure and function of the heart, detecting the presence of pericardial effusion and judging the cause and condition, doctors can fully understand the disease and cause of the patient, and make a more accurate treatment plan. At the same time, by monitoring the change of the disease, the treatment plan can be adjusted in time and the treatment effect can be evaluated.

Ultrasound imaging technology is a valuable tool for detecting myocardial damage and functional abnormalities, including cardiomyocyte necrosis, edema, and fibrosis [26]. These changes enable physicians to determine the presence and severity of myocarditis. For instance, by assessing the abnormal systolic and diastolic function of the heart muscle, the extent of myocarditis can be evaluated. Ultrasound imaging technology can also detect pericardial effusion, providing crucial information about its extent and location, which is significant for the diagnosis and evaluation of myocarditis. By observing changes in cardiac structure and function, ultrasound imaging technology can aid in determining the etiology and status of myocarditis. For example, the presence of coronary arteritis can be identified by examining blood flow in the coronary arteries and myocardial perfusion. Given the symptomatic similarities between myocarditis and other cardiovascular diseases such as myocardial infarction and heart failure, ultrasound imaging technology can provide more information about cardiac structure and function, aiding in differential diagnosis. For instance, assessment of heart muscle fibrosis and necrosis can facilitate differentiation from myocardial infarction. Regular ultrasound imaging can monitor changes in the condition of myocarditis patients, including myocardial damage repair and cardiac function improvement. This facilitates the evaluation of treatment efficacy and the adjustment of treatment plans. Additionally, ultrasound imaging technology can provide information on other organs, such as the liver and spleen, aiding in comprehensive understanding of the patient's condition and its underlying causes.

In the diagnosis and differential diagnosis of myocarditis, ultrasound imaging technology assumes a pivotal role and confers distinct advantages [27]. Firstly, ultrasound imaging technology offers a visual representation of the heart's structure and function, encompassing parameters such as heart cavity size, wall thickness, and cardiac systolic function, thus aiding in the comprehensive evaluation of over-all cardiac health. For patients with myo-carditis, ultrasound can reveal myocardial thickness, as well as local contraction abnormalities, facilitating the detection of myocardial damage and inflammation. Furthermore, through color Doppler technology, ultrasound can assess heart blood flow velocity and direction, evaluate heart valve function, and measure cardiac volume load, thereby providing valuable assistance in differential diagnosis. Secondly, ultrasound imaging technology serves as a real-time dynamic inspection method, furnishing real-time motion images of the heart. This capability enables the observation of heart contraction and diastole, facilitating the timely detection of abnormal movement and myocardial deformation, which holds great significance for early diagnosis and differential diagnosis of myocarditis.

Diagnosis and differential diagnosis of myocarditis by nuclear medicine imaging technology

Nuclear medicine imaging technology, which combines nuclide tracer technology with computer imaging technology, is a non-invasive diagnostic method with significant implications in the diagnosis and differential diagnosis of myocarditis [28]. By utilizing these advanced techniques, doctors can acquire valuable information regarding the structure and function of the heart, enabling early detection and differentiation of myocarditis from other cardiovascular diseases. However, it is important to note that not all patients are suitable candidates for these techniques, and doctors must carefully select the most appropriate diagnostic method based on the individual patient's circumstances.

The diagnosis of myocarditis relies on a combination of factors, including medical history, clinical manifestations, laboratory examinations, and imaging studies [29]. Nuclear medicine imaging techniques, particularly cardiac Single Photon Emission Computed Tomography (SPECT) and Positron Emission Computed Tomography (PET-CT), provide insights into myocardial perfusion and metabolism, aiding in the diagnosis of myocarditis. In the early stages of myocarditis, myocardial perfusion may appear normal, but as the disease progresses, abnormalities in myocardial perfusion can be detected. Nuclear medicine imaging technology can capture these changes, facilitating early diagnosis.

[DOI: 10.61186/ijrr.22.2.243]

Furthermore, PET-CT can offer information on myocardial metabolism, allowing for the assessment of cardiomyocyte viability.

Differential diagnosis of myocarditis is essential to distinguish it from other cardiovascular diseases such as coronary artery disease and hypertensive heart disease. Nuclear medicine imaging technology assists doctors in making accurate differential diagnoses. For instance, in coronary artery disease, nuclear medicine imaging techniques often reveal myocardial underperfusion and ischemia. In contrast, myocardial ischemia is typically absent in myocarditis, although abnormalities in myocardial perfusion may be present. Additionally, PET-CT can provide insights into myocardial metabolism, aiding in the assessment of cardiomyocyte survival.

In summary, nuclear medicine imaging technology, with its integration of nuclide tracer technology and computer imaging technology, plays a crucial role in the diagnosis and differential diagnosis of myocarditis [30]. These techniques provide essential information about myocardial perfusion and metabolism, enabling early detection and differentiation from other cardiovascular diseases. Careful consideration of the patient's condition is necessary when selecting the most appropriate diagnostic method.

Nuclear medicine imaging technology has the capacity to reveal myocardial metabolic abnormalities, encompassing glucose and fatty acid metabolism [31]. Patients with myocarditis may exhibit myocardial cell damage and metabolic irregularities, which can be identified using nuclear medicine imaging techniques. These techniques also enable the assessment of heart function, including ventricular systolic and diastolic function. The observation of such functional irregularities can aid physicians in comprehending the impact of myocarditis on the heart.

By scrutinizing metabolic and functional anomalies in the heart muscle, nuclear medicine imaging technology can assist in determining the etiology and status of myocarditis. For instance, the detection of abnormal glucose metabolism in cardiomyocytes can provide insights into the presence of autoimmune myocarditis. Moreover, nuclear medicine imaging technology can furnish additional details about cardiometabolic and functional conditions, facilitating differential diagnosis. Notably, abnormalities in glucose metabolism in the heart muscle can be discerned from those associated with myocardial infarction. By detecting metabolic and functional alterations in the heart, nuclear medicine imaging technology can aid in ascertaining the cause and condition of myocarditis. For instance, the identification of abnormal fatty acid metabolism in cardiomyocytes can signify the presence of coronary arteritis. Regular employment of nuclear medicine imaging allows for the monitoring of changes in myocarditis patients, including the repair of myocardial damage and the enhancement of cardiac function. This capability supports physicians in evaluating treatment efficacy and adjusting treatment plans.

Advantages and applications of multimodal medical imaging technology

The application prospects of multimodal medical imaging technology are extensive, offering doctors a more comprehensive and accurate understanding of medical information, thereby enhancing the accuracy of diagnosis and treatment [32]. As technology continues to advance and improve, multimodal technology will play an increasingly vital role in the future of medicine.

Multimodal medical imaging technology possesses several advantages. It allows for the simultaneous acquisition of various types of medical image information, including structural, functional, and perfusion images, enabling a more comprehensive assessment of a patient's condition [33]. For instance, in the diagnosis of heart disease, doctors can utilize magnetic resonance imaging (MRI) to obtain structural information about the heart, while PET-CT can provide perfusion and metabolic information about the cardiac muscle. This comprehensive approach facilitates a more accurate evaluation of heart function and condition. By leveraging the complementary nature of multimodal techniques, the accuracy of diagnoses can be significantly improved. In tumor diagnosis, for example, CT can provide structural information about tumors, while PET can offer metabolic information, aiding in a more precise assessment of tumor nature and extent.

Moreover, multimodal medical imaging technology enables the development of personalized treatment plans for patients. By analyzing a patient's medical images, doctors can gain insights into the patient's condition, the extent and severity of lesions, and other pertinent information, allowing for the formulation of tailored treatment strategies [34]. Additionally, multimodal techniques can be employed to evaluate the effectiveness of treatments. In cancer treatment, for instance, doctors can assess treatment outcomes by comparing medical images taken before and after treatment, enabling timely adjustments to the treatment plan.

In summary, multimodal medical imaging technology holds great promise in the medical field, offering doctors a more comprehensive and accurate understanding of medical information. Its ability to provide multiple types of imaging data simultaneously allows for a more precise assessment of patient conditions, facilitates personalized treatment planning, and enables the evaluation of treatment effectiveness. As technology continues to evolve, multimodal techniques will continue to play an increasingly significant role in advancing medical practice.

The integration of multimodal medical imaging technology assumes a critical role in the diagnosis and treatment of heart disease, as well as in tumor diagnosis, treatment, and evaluation [35]. Magnetic resonance imaging (MRI) and echocardiography (ECHO) are utilized to evaluate the heart's structure and function, while PET-CT is employed to assess the perfusion and metabolism of the heart muscle. In the realm of tumor diagnosis and treatment, CT and MRI are employed to analyze tumor structural information, and PET is utilized to evaluate tumor metabolism. Moreover, multimodal medical imaging technology plays a pivotal role in the diagnosis and treatment of neurological diseases, with MRI being used to assess brain structure and function, and PET being employed to evaluate brain metabolism. This versatile imaging technology can also be applied to other diseases such as diabetes and rheumatoid arthritis. For instance, PET-CT can be utilized to assess organ perfusion and metabolism, thereby providing physicians with a more comprehensive understanding of the patient's medical condition.

Challenges and prospects of differential diagnosis using multimodal medical imaging technology

The diagnosis and differential diagnosis of myocarditis based on multimodal medical imaging technology faces some challenges and limitations in clinical practice. Multimodal medical imaging technology provides a lot of information, but the evaluation criteria and interpretation criteria of various technologies are different, which may lead to certain differences in diagnostic results [36]. Although the multimodal medical imaging technology has made remarkable progress, there are still some limitations. For example, some techniques may have limited sensitivity to specific organs or diseases, leading to the possibility of missed diagnosis or misdiagnosis. Multimodal medical imaging technology usually requires expensive equipment and professional technicians, which limits its popularization and application in clinical practice [37]. In addition, certain technologies may be unavailable or costly in certain regions. Multimodal medical imaging technology generates a large amount of data, and how to effectively integrate and interpret these data is a challenge. Methods of data analysis and interpretation need to be developed to take full advantage of the information provided by these data.

The future development trend of multimodal medical imaging technology is poised for continuous growth and innovation driven by scientific and technological advancements. Anticipated breakthroughs may introduce more sensitive and specific techniques to enhance the diagnostic accuracy of myocarditis. As big data and artificial intelligence technology progress, in-depth data mining and analysis of multi-modal medical image data will emerge as crucial research directions. Machine learning and deep learning methods, for instance, can effectively extract diagnostic information from image data, thereby improving diagnostic efficiency [38].

The diagnosis and differential diagnosis of myocarditis necessitate multidisciplinary collaboration among fields such as medical imaging, cardiology, and infection. Strengthening interdisciplinary cooperation to facilitate discussions and research on the diagnosis and treatment of myocarditis will contribute to elevating the standards of diagnosis and treatment. To address the strengths and limitations of multimodal medical imaging technology in the diagnosis of myocarditis, clinical translational research should be conducted to explore optimal applications of these technologies in clinical practice, enhancing diagnostic accuracy and accessibility.

Efforts should also be directed towards training and educating healthcare professionals in the specialized knowledge and skills required for multimodal medical imaging technology. This will enhance the diagnostic capabilities and technical proficiency of clinicians and medical imaging practitioners, ultimately facilitating the widespread adoption and application of multimodal medical imaging techniques in the diagnosis of myocarditis.

The diagnosis and differential diagnosis of myocarditis based on multimodal medical imaging technology has important application value in clinical practice, but it also faces some challenges and limitations. Future research and exploration are needed to overcome these challenges, promote the development of multimodal medical imaging technology, and improve the diagnostic accuracy and treatment effectiveness of myocarditis. The following table summarizes the differences in sensitivity of various multimodal medical imaging techniques for the diagnosis and differential diagnosis of myocarditis:

Table 1. Sensitivity differences of various multimodal medical imaging techniques in the diagnosis and differential diagnosis of myocarditis.

Imaging Modality	Sensitivity for Myocarditis Diagnosis	Sensitivity for Differential Diagnosis
X-ray	Low	Moderate
CT	Moderate	High
MRI	High	High
Ultrasound	Low	Low
Nuclear Medicine	Moderate to High	High

Conclusion and prospect

Multimodal medical imaging technology has important application value in the diagnosis and differential diagnosis of myocarditis. Through X-ray imaging, CT imaging, MRI imaging, nuclear medicine imaging and other technologies, the structure and

[DOI: 10.61186/ijrr.22.2.243]

function information of the heart and great blood vessels can be obtained, providing more basis for doctors' diagnosis. However, there are still some challenges and limitations in the application process, such as the selection and interpretation of image technology, early diagnosis and disease monitoring, differential diagnosis and disease typing.

In the future, the advancement and refinement of imaging technology are imperative to foster innovation and development. Efforts should be made to enhance the integration and information sharing of multi-modal imaging techniques, while harnessing the power of artificial intelligence (AI) to enhance diagnostic accuracy and objectivity. Novel medical imaging methods should be pursued to elevate the diagnostic precision and early detection rate of myocarditis. For instance, the exploration of new, highly sensitive MRI and nuclear medicine techniques can aid in the timely identification of early heart muscle lesions. Furthermore, the integration and information sharing between diverse imaging technologies should be explored to bolster diagnostic accuracy and reliability. By employing techniques such as data fusion and image reconstruction, the information from different imaging modalities can be integrated and analyzed, thereby providing a more comprehensive diagnostic foundation.

The utilization of AI technology is crucial in establishing diagnostic support systems that enhance objectivity and accuracy. Through techniques like deep learning, medical images can be automatically interpreted and analyzed, providing doctors with diagnostic recommendations and treatment suggestions. In conclusion, multi-modal medical imaging technology holds immense potential in the diagnosis and differential diagnosis of myocarditis. Future research and exploration are vital to address existing challenges and limitations, propelling the advancement of cardiovascular disease diagnosis and treatment, particularly in cases of myocarditis. Concurrently, strengthening international cooperation and academic exchanges is essential to collectively promote the diagnosis and treatment of cardiovascular diseases, including myocarditis.

ACKNOWLEDGEMENT

The author of this article would like to thank the following experts and people for their help: Hong Chen provided the data collected with imaging equipment. Wenzeng Wang, Daqing Feng, Qiannan Song, Wenhui Sun, Die Zhang, Miao Li and Kexin Li participated in the engineering sampling. Thank you to Hong Chen for your valuable advice!

Conflict of interests**:** The authors declare that they have no conflict of interests.

Funding**:** The 13th batch of special funding from China Postdoctoral Science Foundation (Station) No. 2020T130178.

Authors' contribution**:** The literature search was conducted by Hong Chen, the survey design of this paper was Wenzeng Wang, Daqing Feng, Wenhui Sun, Die Zhang, Miao Li and Kexin Li, and the result of this paper was written as XXX. The paper is discussed and analyzed as Qiannan Song.

REFERENCES

1. Asllanaj B, Chang E, Dota A, McWhorter Y (2022) Myocarditis mimicking ST-segment elevation myocardial infarction complicated by thrombocytopenia and vasculitic peripheral neuropathy. *Journal of Investigative Medicine High Impact Case Reports*, ***10**: 1615987015*.
2. Altman NL, Berning AA, Mann SC, *et al.* (2023) Vaccination-Associated Myocarditis and Myocardial Injury. *Circ Res, **132** (10):1338-1357*.
3. Kumar P, Arendt C, Martin S, *et al.* (2023) Multimodality imaging in HIV-associated cardiovascular complications: A comprehensive review. *Int J Environ Res and Pub Health*, ***20**(3): 2201.*
4. Cioffi I, Ponzo V, Pellegrini M, *et al.* (2021) The incidence of the refeeding syndrome. A systematic review and meta-analyses of literature. *Clin Nutr, **40**(6): 3688-3701*.
5. Bartlett DJ, Takahashi H, Bach CR, *et al.* (2023) Potential applications of PET/MRI in non-oncologic conditions within the abdomen and pelvis. *Abdom Radiol (NY), **48**(12): 3624-3633*.
6. Remels A, Derks W, Cillero-Pastor B, *et al.* (2018) NF-kappaB-mediated metabolic remodelling in the inflamed heart in acute myocarditis. *Biochimica Et Biophysica Acta-Molecular Basis of Disease*, ***1864**(8): 2579-2589*.
7. Hoya Y, Mitsumori N, Yanaga K (2009) The advantages and disadvantages of a Roux-en-Y reconstruction after a distal gastrectomy for gastric cancer. *Surg Today, **39**(**8**): 647-51*.
8. Arçay Öztürk A and Flamen P (2023) FAP-targeted PET imaging in gastrointestinal malignancies: a comprehensive review. *Cancer Imaging, **23**(1): 79*.
9. Jeong D, Gladish G, Chitiboi T, *et al.* (2019) MRI in cardio-oncology: A review of cardiac complications in oncologic care. *J Magn Reson Imaging, **50**(5): 1349-1366*.
10. Chareonthaitawee P and Gutberlet M (2023) Clinical utilization of multimodality imaging for myocarditis and cardiac sarcoidosis. *Circulation-Cardiovascular Imaging*, ***16**(1): e014091*.
11. Villemain O, Baranger J, Jalal Z, *et al.* (2020) Non-invasive imaging techniques to assess myocardial perfusion. *Expert Rev Med Devices, **17**(11):1133-1144*.
12. McKenna WJ and Caforio ALP (2022) Myocardial inflammation and sudden death in the inherited cardiomyopathies. *Can J Cardiol, **38** (4): 427-438*.
13. Pogue BW and Wilson BC (2018) Optical and X-ray technology synergies enabling diagnostic and therapeutic applications in medicine. *J Biomed Opt, **23**(12):1-17*.
14. Snekhalatha U, Rajalakshmi T, Gopikrishnan M, *et al.* (2017) Computer-based automated analysis of X-ray and thermal imaging of knee region in evaluation of rheumatoid arthritis. *Proc Inst Mech Eng H, **231(**12):1178-1187*.
15. Yang Z, Zhang P, Chen X, *et al.* (2022) High-confidentiality X-ray imaging encryption using prolonged imperceptible radioluminescence memory scintillators. *Adv Mater, **35(**52): e2309413*.
16. Sun J, Wu Z, Yu Z, *et al.* (2022) Automatic video analysis framework for exposure region recognition in X-Ray imaging automation. *IEEE J Biomed Health Inform, **26**(9): 4359-4370*.
17. Kirkbride RR, Rawal B, Mirsadraee S, *et al.* (2021) Imaging of cardiac infections: A comprehensive review and investigation flowchart for diagnostic workup. *Journal of Thoracic Imaging*, ***36**(5): W70-W88*.
18. Citro R, Pontone G, Bellino M, *et al.* (2021) Role of multimodality imaging in evaluation of cardiovascular involvement in COVID-19. *Trends in Cardiovascular Medicine*, ***31**(1): 8-16*.
19. Rudski L, Januzzi JL, Rigolin VH, *et al.* (2020) Multimodality imaging in evaluation of cardiovascular complications in patients with COVID-19: JACC scientific expert panel. *Journal of the American College of Cardiology*, ***76**(11): 1345-1357*.
20. Van Linthout S, Elsanhoury A, Klein O, *et al.* (2018) Telbivudine in chronic lymphocytic myocarditis and human parvovirus B19 transcriptional activity. *Esc Heart Failure*, ***5**(5): 818-829*.
21. Prameswari HS, Balakrishnan ID, Khoo CY, *et al.* (2021) The role of

multimodality imaging in diagnosing acute perimyocarditis secondary to Crohn's disease. *Bmc Cardiovascular Disorders*, ***21****(1): 427*.
22. von Olshausen G, Hyafil F, Langwieser N, *et al.* (2014) Detection of acute inflammatory myocarditis in Epstein Barr virus infection using hybrid 18F-fluoro-deoxyglucose-positron emission tomography/magnetic resonance imaging. *Circulation*, ***130****(11): 925-926*.
23. Yamamoto H and Isogai J (2023) Transient constrictive pericarditis following coxsackievirus A4 infection as a rare cause of acute mediastinitis: A case report. *Heliyon*, ***9****(9): e19555*.
24. Baldassarre LA, Ganatra S, Lopez-Mattei J, *et al.* (2022) Advances in multimodality imaging in cardio-oncology: JACC state-of-the-art review. *Journal of the American College of Cardiology*, ***80****(16): 1560-1578*.
25. Muscogiuri G, Guaricci AI, Cau R, *et al.* (2022) Multimodality imaging in acute myocarditis. *Journal of Clinical Ultrasound*, ***50****(8): 1097-1109*.
26. Diesch ST, Jung F, Prantl L, *et al.* (2022) Surface imaging of breast implants using modern high-frequency ultrasound technology in comparison to high-end sonography with power analyses for B-scan optimization1. *Clin Hemorheol Microcirc,* ***80****(4):487-495*.
27. Senel M, Schlensak C, Gawaz MP, *et al.* (2023) Myocardial abscess after myocarditis: Advantages of multimodal imaging detecting the rare case of fungal abscess. *Jacc Case Rep*, ***6****: 101694*.
28. Pizzino F, Vizzari G, Qamar R, *et al.* (2015) Multimodality imaging in cardiooncology. *Journal of Oncology*, ***2015****: 263950*.
29. Cardoso R and Leucker TM (2020) Applications of PET-MR imaging in cardiovascular disorders. *PET Clinics*, ***15****(4): 509-520*.
30. O'Connor MJ (2019) Imaging the itis: endocarditis, myocarditis, and pericarditis. *Current Opinion in Cardiology*, ***34****(1): 57-64*.
31. Bocklitz TW, Salah FS, Vogler N, *et al.* (2022) Pseudo-HE images derived from CARS/TPEF/SHG multimodal imaging in combination with Raman-spectroscopy as a pathological screening tool. *BMC Cancer,* ***16****:534*.
32. Korosoglou G, Alizadehsani R, Islam S, Rolf A (2023) Editorial: Contemporary causes of acute myocarditis and pericarditis: diagnosis by advanced imaging techniques and therapeutic strategies. *Frontiers in Cardiovascular Medicine*, ***10****: 1211463*.
33. Ma J, Li P, Wang W (2018) Biodegradable Poly(amino acid)-Gold-Magnetic Complex with Efficient Endocytosis for Multimodal Imaging-Guided Chemo-photothermal Therapy. *ACS Nano,* ***12****(9): 9022-9032*.
34. Czernin J (2019) Toward independent nuclear medicine, molecular imaging, and theranostic programs. *J Nucl Med,* ***60****(8):1037*.
35. Giorgetti A, Genovesi, Emdin M (2021) The role of 18FDG PET/CT in the assessment of endocarditis, myocarditis and pericarditis. *Current Radiopharmaceuticals*, ***14****(3): 259-272*.
36. Zubin MP, Narula N, Narula J (2021) Somatostatin receptor imaging in active cardiac sarcoidosis: Would less be enough? *Journal of Nuclear Cardiology*, ***28****(3): 1100-1104*.
37. Contaldi C, Montesarchio V, Catapano D, *et al.* (2023) Multimodality cardiovascular imaging of cardiotoxicity due to cancer therapy. *Life-Basel*, ***13****(10): 2103.*
38. Horgan SJ, Mediratta A, Gillam LD (2020) Cardiovascular imaging in infective endocarditis: A multimodality approach. *Circulation-Cardiovascular Imaging*, ***13****(7): e008956*.

[DOI: 10.61186/ijrr.22.2.243]