Clinical Application and Development of Ultrasound Diagnosis Technology for Cardiac and Vascular Diseases

Kana Li
Zhuji People's Hospital of Zhejiang Province, Zhuji 311800, Zhejiang, China
DOI: 10.32629/jcmr.v5i3.2788

Abstract: With the rapid development of medical technology, ultrasound diagnostic technology plays an increasingly important role in the diagnosis and treatment of cardiac and vascular diseases,ultrasound diagnostic technology has been favored by patients and doctors. Based on this, this study further explores the practice and development prospects of ultrasound diagnostic technology in related fields with the research contents of ultrasound diagnostic technology and patients with cardiovascular diseases.
***Keywords*:** heart; vascular disease; ultrasound diagnostic technology; clinical application

1. Current status of ultrasound diagnosis for cardiac and vascular diseases

The ultrasound diagnosis of cardiovascular diseases mainly includes echocardiography, intravascular ultrasound, Doppler ultrasound and other technologies, by imaging the human body through high-frequency sound waves, to observe the structure and function of the heart and blood vessels. As the basis of cardiovascular ultrasound diagnosis, echocardiography can show the size, morphology, the activity of the valve and the motor function of the heart. Two-dimensional echocardiography can observe the structure of the heart from multiple angles, while three-dimensional echocardiography can present the three-dimensional structure of the heart more intuitively, providing doctors with more accurate diagnostic information. Intravascular ultrasound places a miniaturized ultrasound transducer into the cardiovascular lumen through a cardiac catheter to show the cardiovascular sectional morphology and blood flow pattern. It can not only observe the morphology, thickness and plaque of the blood vessel wall, but also evaluate the speed and direction of blood flow, providing an important basis for the diagnosis and treatment of atherosclerosis. Doppler ultrasound is able to measure the blood flow velocity and direction, and is valuable for the diagnosis of hemodynamic abnormalities such as valve stenosis and regurgitation. It also evaluates the ability of the heart to pump blood and the movement of the ventricular wall.Echocardiography has become an indispensable tool in the diagnosis of cardiovascular disease.

To sum up, echocardiographic techniques can not only observe the morphology, size and movement, but also the systolic and diastolic function and the opening and closure of the heart valve[1] . Vascular ultrasound can observe parameters such as the thickness of the vessel wall, plaque formation and blood flow velocity, so as to determine whether the vessel has lesions such as stenosis, blockage or sclerosis.

2. Clinical application of ultrasound diagnosis technology for cardiovascular diseases

2.1 A comprehensive assessment of cardiac structure and function

Ultrasound diagnosis plays an irreplaceable role in the diagnosis of heart disease. Through different ultrasound examination methods, such as M, B and color Doppler ultrasound, doctors can intuitively observe the shape, size, wall thickness and motion of the heart, and help to help in the detection of abnormalities of the heart structure, such as heart valve lesions, ventricomas, cardiac hypertrophy, etc. At the same time, ultrasound technology can also monitor the contraction and diastolic function of the heart in real time, evaluate the pumping ability of the heart, and provide an important basis for the diagnosis and treatment of heart disease[2].

In terms of clinical application, ultrasound diagnostic technology has become an important means of cardiac disease detection. This technique can be used not only to observe the morphology and structure of the heart, but also to deeply analyze their movement and hemodynamic characteristics. Doctors can use the diagnostic ultrasound technique to accurately measure the chamber size, myocardial thickness and movement state, while observing the valve morphology and function of the heart. At the same time, the introduction of CEUS, intraluminal ultrasound and other technologies has further improved the accuracy and sensitivity of ultrasound diagnosis. The clinical application of these technologies is not only conducive to the early detection of cardiac diseases, but also provides an important basis for the accurate diagnosis and effective treatment

of diseases.

2.2 Accurate diagnosis of vascular diseases

Diagnostic ultrasound techniques also have significant advantages in the diagnosis of vascular diseases. Using the high-frequency ultrasonic probe, doctors can clearly observe the inner diameter, wall thickness, blood flow velocity and other indicators of blood vessels, so as to judge whether there are stenosis, plaque, thrombosis and other lesions of blood vessels. This is of great significance for the early detection and treatment of vascular diseases such as arteriosclerosis and thrombotic diseases[3].

With the continuous progress of the technology, the ultrasound diagnosis technology of vascular diseases is also constantly developing. The advent of three-dimensional and four-dimensional ultrasound imaging techniques has allowed doctors to more comprehensively assess the structure and function of the blood vessels.

3. Advantages of Ultrasound Diagnosis Technology

As a non-invasive, non-side-effect examination method, diagnostic ultrasound technology has a unique advantage in the diagnosis of cardiovascular diseases. Compared with other imaging methods, such as X-ray and CT, ultrasound examination has no radiation damage to the patient. At the same time, ultrasound examination operation is simple and convenient, can be carried out at the bedside, suitable for a variety of patient groups, including children, pregnant women and other special groups.

In addition, ultrasound examination also has the characteristics of good reproducible, patients can be followed up for many times, in order to detect changes in time. This enables diagnostic ultrasound techniques to play an important role in the long-term monitoring and prognosis evaluation of cardiovascular diseases.

Through the comprehensive evaluation of cardiac structure and function, the precise diagnosis of vascular diseases, and the advantages of no trauma and no side effects, ultrasound diagnostic technology provides strong support for the diagnosis and treatment of cardiovascular diseases. With the continuous development and improvement of ultrasound technology, it is believed that its application in the cardiovascular field will be more extensive and deep.

4. Challenges faced

4.1 Technical Limitations

The interpretation of ultrasound images requires highly specialized and experienced physicians, which partly limits its widespread application. In the meanwhile, ultrasonic propagation is severely affected by bone and air. The high bone density and strong absorption and reflection of the ultrasound waves make it difficult to penetrate the bone to reach the following tissue. Similarly, air is also a good barrier for ultrasonic propagation, making the lungs and other gas-containing organs become a blind spot for ultrasonic diagnosis. Despite the superior penetration of ultrasound in fluid and soft tissue, it may be inadequate for the examination of deep tissue or obese patients. Although modern ultrasound devices have greatly improved the resolution and clarity of images, they may still not meet the clinical needs in some complex situations, such as small vessel lesions, tiny thrombus, etc. This may lead to a missed diagnosis or a misdiagnosis [4].

4.2 Individual patient differences

Obese patients have a thicker subcutaneous fat layer, which can significantly absorb ultrasound energy, leading to weakened ultrasound penetration and decreased image quality, thus affecting the accuracy of diagnosis. In the meanwhile, The anatomy of the heart and large blood vessels varies between individuals, such as the location, size, shape, and the walking of blood vessels. The physiological status (such as heart rate, breathing, blood pressure, etc.) at the time of ultrasound diagnosis may fluctuate due to tension, anxiety, or the disease itself [5].

4.3 Equipment cost

High-end cardiovascular ultrasound diagnostic systems are very expensive to purchase. In addition to the purchase cost, the maintenance and upgrade of ultrasound diagnostic equipment is also a large expense. With the continuous progress of technology, ultrasound diagnostic equipment requires regular software upgrades and hardware maintenance to ensure stable performance and accuracy. These maintenance and upgrade costs are usually high and gradually increase with longer equipment use time. In addition, some high-end equipment also needs maintenance and operation by professional technicians, which also increases the labor cost of medical institutions. In order to recover equipment investment and maintain operation, medical institutions often set higher fees in ultrasound examination programs. This is undoubtedly a heavy burden for patients with poor economic conditions.

5. Improve countermeasures

5.1 Optimize the ultrasound diagnostic plan

Ultrasound diagnostic technology is favored by doctors and patients for its noninvasive, real-time and reproducible advantages. In the diagnosis of heart disease, ultrasound technology can clearly show the structure and function of the heart, thus helping doctors to find heart valve lesions, myocardial hypertrophy, pericardial effusion and other abnormalities. At the same time, by measuring the heart's ejection fraction, blood flow velocity and other parameters, doctors can also assess the state of the heart function of the patient, providing key information for the development of treatment strategies. Therefore, hospitals and medical institutions should update their equipment to ensure that it meets international safety and quality standards, and conduct regular maintenance and calibration to maintain their best performance. Focus on the latest developments in ultrasound techniques, such as multi-frequency probes, 3 D imaging, elastography, and consider applying these new technologies in clinical practice[6].

In addition, develop and implement standardized ultrasound examination procedures, such as patient preparation, examination process, image acquisition, and report writing. Reduce unnecessary steps and waiting time through process optimization to improve the inspection efficiency. Using the medical information system (HIS) and ultrasonic image archiving and communication system (PACS) and other information means, to realize the electronic appointment, inspection, report and other links. Through data analysis and mining, optimize the resource allocation and process management, and improve the overall operational efficiency[7].

5.2 Strengthen the doctor training and improve the interpretation ability

With the continuous progress of technology, ultrasound diagnostic technology is constantly developing and innovating, providing doctors with more rich and fine diagnostic information. In clinical application, the ultrasonic diagnostic technology of cardiac and vascular diseases can intuitively demonstrate the structure and function of the heart and blood vessels, and help doctors to find potential lesions[7], such as myocardial hypertrophy, valvular abnormalities, vascular stenosis and so on. By observing blood flow in real time, ultrasound diagnosis can also provide doctors with critical information about hemodynamics. Therefore, doctors need to master the basic principles and operation methods of ultrasound diagnosis, and be familiar with the ultrasound manifestations of various cardiac and vascular diseases, so as to be able to accurately identify the lesions and make a correct diagnosis. At the same time, doctors also need to have rich clinical experience and keen insight in order to capture key information in complex ultrasound images and improve the accuracy and reliability of diagnosis.

Organize specialized ultrasound skills training courses, covering ultrasound skills in the heart, blood vessels, abdomen, superficial organs and other fields. Improve doctors' practice and operational ability through simulated operation and case analysis. Using ultrasound simulator and virtual reality technology, we provide doctors with a near real ultrasound diagnostic environment and conduct a lot of practical exercises. Simulate different disease states and complex cases to improve doctors' resilience and diagnostic accuracy. During the practical operation exercise, experienced mentors are provided to provide real-time guidance and feedback. Point out the shortcomings and mistakes of the doctors in the operation, and help them to correct and improve them in time.Regular ultrasound diagnosis seminars and academic exchange meetings are organized, and well-known experts at home and abroad are invited to give lectures and share. Let doctors know the latest ultrasound diagnostic technology and research results, broaden their vision and improve their professional quality. Doctors are encouraged to participate in various continuing education programs, such as online courses, advanced classes, seminars, etc. Constantly update the knowledge structure, master the latest ultrasonic diagnostic technology and methods.

5.3 Timely maintenance and update of equipment to reduce costs

The performance and accuracy of the equipment directly affect the reliability of the diagnostic results. Therefore, medical institutions should regularly maintain and maintain the ultrasound diagnostic equipment to ensure that it is in the best working condition. At the same time, with the continuous emergence of new technologies, medical institutions also need to update their equipment in time to meet the needs of clinical diagnosis and treatment. Cost reduction is also an important direction for the development of ultrasound diagnostic technology. This includes improving the efficiency of the equipment, reducing maintenance costs, and optimizing the diagnostic process. Through scientific equipment management and use, medical institutions can reduce unnecessary waste and improve the economic benefits of ultrasound diagnosis[8].

6. Summary

Ultrasound diagnosis technology of cardiac and vascular diseases is playing an increasingly important role in the diagnosis, treatment and prognosis evaluation of cardiac and vascular diseases. Ultrasonic diagnostic technology has the

advantages of non-invasive, real-time and repeatable, which can intuitively observe the structure and function of the heart and blood vessels, and help doctors to find potential lesions, such as myocardial hypertrophy, valve abnormalities, vascular stenosis, etc. Ultrasound diagnostic technology has significant advantages in the diagnosis of cardiovascular disease, which can provide doctors with key information about hemodynamics and facilitate the judgment of disease severity and prognosis. Compared with other imaging methods, such as X-ray and CT, ultrasound examination has no radiation damage to the patient. At the same time, ultrasound examination is simple and convenient, can be carried out at the bedside, suitable for all variety of patients.

All in all, ultrasound diagnostic technology plays an irreplaceable role in the diagnosis of cardiovascular diseases with its advantages of noninvasive, real-time and reproducible. With the continuous progress of science and technology, ultrasonic diagnostic technology is also developing. In the future, the ultrasonic diagnosis technology of cardiovascular diseases will be more intelligent and refined.

References

[1] Surkova E, Peluso D, Kasprzak JD, et al. Use of novel echocardiographic techniques to assess right ventricular geometry and function[J]. Kardiol Pol, 2016,74(6):507-22.

[2] Sun ZY, Li Q, Li J, et al. Echocardiographic evaluation of the right atrial size and function: Relevance for clinical practice[J]. Am Heart J Plus, 2023,27:100274..

[3] Al-Kazaz M, Ramesh A, Maganti K. The Echocardiographic Evaluation of Aortic Aneurysm[J]. Curr Cardiol Rep, 2022,24(12):1893-1900..

[4] Kyrouac D, Schiffer W, Lennep B, et al. Echocardiographic and clinical predictors of cardiac amyloidosis: limitations of apical sparing[J]. ESC Heart Fail, 2022,9(1):385-97.

[5] Singh M, Sethi A, Mishra AK, et al. Echocardiographic Imaging Challenges in Obesity: Guideline Recommendations and Limitations of Adjusting to Body Size[J]. J Am Heart Assoc, 2020,9(2):e014609.

[6] White BR, Chaszczewski KJ, Lemley B, et al. Sustained improvement in fellows' echocardiographic completeness through the coronavirus pandemic with a standardised imaging protocol[J]. Cardiol Young, 2022:1-7.

[7] Hensel KO. Time to shape up - assessment and reporting standards for data quality in clinical research using echocardiographic imaging techniques require improvement[J]. BMC Cardiovasc Disord, 2019,19(1):281.

[8] Jone PN, Gould R, Barrett C, et al. Data-Driven Quality Improvement Project to Increase the Value of the Congenital Echocardiographic Report[J]. Pediatr Cardiol, 2018,39(4):726-30.

Author Bio

Li Kana (1983.05-), female, Han nationality, Zhejiang Zhuji, undergraduate, deputy chief physician. Research interests: ultrasound diagnosis of cardiac and vascular diseases