ECHOCARDIOGRAPHY AND ITS APPLICATIONS IN CARDIOVASCULAR DISEASE DIAGNOSIS

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Abstract. *This thesis shows the role of echocardiography in the diagnosis and management of cardiovascular diseases. It begins by providing a comprehensive overview of cardiovascular diseases and their prevalence, highlighting the need for accurate and timely diagnosis. The thesis then delves into the principles of echocardiography, describing the different types of imaging modalities and their applications in cardiovascular disease diagnosis. Moreover, it discusses the advantages and limitations of echocardiography, including its non-invasiveness, portability, and relatively low cost. It concludes by considering the importance of echocardiography in ameliorating patient outcomes and reducing the burden of cardiovascular diseases on society.*

Keywords: *Echocardiography, M-mode echocardiography, two-dimensional echocardiography, Doppler echocardiography, transthoracic echocardiography, transesophageal echocardiography, esophagus, stroke volume (SV), ventricular wall, myocardium, left ventricular volume (LVV), ejection fraction (EF).*

Introduction.

The result of the progress of society, people's living standards are significantly advancing, and human health has become the focus of people's attention. One of the main causes of death worldwide is heart disease, and effective treatment depends on early detection. It has become more important to employ echocardiography, a non-invasive imaging technology that uses ultrasonic waves to create precise images of the heart, to diagnose a variety of cardiac problems. The way we approach the diagnosis and treatment of heart disease has been transformed by echocardiography, which can see the anatomy and function of the heart in real-time. This thesis seeks to investigate the numerous ways that echocardiography is used to diagnose heart diseases. The many types of echocardiography techniques, their benefits and drawbacks, and their clinical applications will also be covered in this thesis. In recent years, many researchers have studied the treatment of acute myocardial infarction. Many different methods have been found to diagnose patients with cardiovascular diseases, such as M-mode echocardiography, two-dimensional echocardiography, Doppler echocardiography, etc. [1]. For the prognostic assessment of cardiovascular diseases, echocardiography is the most important evaluation method taking all factors into consideration [2,3]. Conventional two-dimensional echocardiography requires geometric assumptions of the ventricular chamber, and then volume parameters can be calculated according to the formula. However, when various reasons lead to remodeling of left ventricular and deformation of cardiac chambers, the morphology of the left ventricle is not regular, and oblique cutting is often caused by detecting the cutting surface of the apex of the heart. Both the technical error and the measurement error increase obviously, which leads to the measurement error of left heart function. A number of studies have shown that real-time three-dimensional echocardiography does not rely on geometric assumptions when measuring parameters such as cardiac function [4].

By providing an in-depth analysis of its applications, the thesis aims to highlight the critical role that echocardiography plays in improving patient outcomes and ultimately reducing the burden of heart disease on society.

Using echocardiography in using to diagnosis cardiovascular diseases.

Overall, the basic principles of echocardiography involve the transmission and reception of sound waves, the formation of images using those waves, and the use of Doppler ultrasound to assess blood flow. These principles allow clinicians to non-invasively evaluate the structure and function of the heart, making echocardiography a valuable diagnostic tool for the evaluation of cardiovascular diseases. Sound wave transmission: A transducer is placed on the chest wall or inside the esophagus, which emits high-frequency sound waves. These waves pass through the chest and are reflected off the structures of the heart. Sound wave reception: The reflected sound waves are picked up by the transducer and converted into electrical signals. Image formation: The electrical signals are processed by a computer and transformed into two-dimensional or three-dimensional images of the heart. These images can be viewed in real-time or stored for later analysis. Doppler ultrasound: Another important principle of echocardiography is the use of Doppler ultrasound, which can detect the direction and speed of blood flow through the heart. Doppler ultrasound can be used to evaluate blood flow across heart valves, detect abnormalities in blood flow, and assess the severity of valve stenosis or regurgitation.

Echocardiography can be performed using different techniques, including transthoracic echocardiography, which is performed by placing a transducer on the chest wall, and transesophageal echocardiography, which is performed by placing a transducer inside the esophagus. Other types of echocardiography include stress echocardiography, which is performed during exercise or medication-induced stress, and contrast echocardiography, which involves injecting a contrast agent into the bloodstream to improve image quality.

To take accurate diagnosis, myriad types of echocardiography applications are used in medicine. Real-time three-dimensional echocardiography is one of the examples of echocardiography. It is as a new technology of ultrasonic diagnosis, is noninvasive, accurate and reliable in the diagnosis of ventricular aneurysm based on three-dimensional probe imaging technology. It can accurately reflect the three-dimensional spatial structure of the cordis, three-dimensional spatial distribution and spatial adjacent relations, and accurately calculate parameters such as left ventricular volume and cardiac function through the extraction of ventricular volume [5]. Especially for the calculation of left ventricular volume and cardiac function under pathological conditions, it has not limitations by the geometric hypothesis of left ventricular morphology. Its measurements of left ventricular volume (LVV), ejection fraction (EF), and stroke volume (SV) have good correlation and consistency with MRI. Compared with the traditional two-dimensional echocardiography, it can more accurately and quantitatively evaluate the segmental systolic function and overall diastolic function of the left ventricular wall and can dynamically and intuitively observe the movement of the left ventricular walls. For the myocardium at the site of myocardial infarction, not only the thickness of the ventricular wall can be observed, but also the obvious movement abnormalities of the ventricular wall can be observed [5].

The most commonly used technique among these is transthoracic echocardiography (TTE). This allows the clinician to obtain real-time sizes, structure, and function of the heart during the cardiac cycle. Another useful and important use of these methods is stress echocardiography. Stress echocardiography is the combination of standard transthoracic echocardiography and either pharmacological or physical stress to the cardiac structures to assess wall motion abnormalities. Physical stresses may include running on a treadmill, and pharmacological stress, including medications.

Transesophageal echocardiography (TEE) is a type of echocardiography that involves inserting a specialized probe into the esophagus to obtain high-quality images of the heart and its structures.

During a TEE, the patient is usually given a sedative to help them relax, and the probe is inserted through the mouth and down the esophagus, which is located behind the heart. The probe emits sound waves that bounce off the heart, creating detailed images that are transmitted to a monitor for the doctor to evaluate.

TEE is often used in situations where traditional transthoracic echocardiography (TTE) may not provide sufficient information. Some indications for TEE include:

Evaluation of the structure and function of heart valves, especially in cases of suspected valvular heart disease or endocarditis. Assessment of blood flow through the heart, especially in patients with congenital heart disease, complex cardiac abnormalities, or suspected intracardiac shunts.

- Detection of blood clots or other abnormalities in the atria, especially in patients with atrial fibrillation or a history of embolic events.
- Guidance of interventions such as transcatheter valve replacement or closure of defects.

TEE has several advantages over TTE, including better visualization of certain structures of the heart due to the proximity of the esophagus to the heart, improved image quality due to the absence of air in the esophagus, and the ability to perform the procedure even in patients with chest wall deformities or obesity that may interfere with TTE imaging. However, TEE also has some risks and limitations, including the potential for complications such as bleeding, esophageal injury, or aspiration, as well as the need for specialized equipment and trained personnel. Nonetheless, TEE remains a valuable tool in the diagnosis and management of cardiovascular diseases.

Stress echocardiography is a type of echocardiography that is used to evaluate the function of the heart before and after a physical stress test, such as exercise or pharmacological stress. The aim of stress echocardiography is to assess the heart's response to stress and identify any abnormalities in blood flow or heart function that may not be present at rest.

During a stress echocardiogram, the patient is usually asked to exercise on a treadmill or cycle ergometer to increase their heart rate and workload. Alternatively, a medication such as dobutamine may be administered to simulate the effects of exercise. As the heart works harder, the echocardiography probe is used to obtain images of the heart and its structures, including the chambers, valves, and blood vessels. These images are then compared to the baseline images obtained at rest.

Stress echocardiography can be used to diagnose and evaluate a variety of cardiovascular conditions, including:

- Coronary artery disease - Stress echocardiography can identify areas of the heart that are not receiving adequate blood flow due to blocked or narrowed coronary arteries.
- Valvular heart disease - Stress echocardiography can evaluate the function of heart valves under stress, helping to diagnose or assess the severity of valvular heart disease.
- Cardiomyopathies - Stress echocardiography can evaluate the function of the heart muscle under stress, helping to diagnose or assess the severity of cardiomyopathies.

- Exercise-induced arrhythmias - Stress echocardiography can detect abnormal heart rhythms that may be triggered by exercise.

Real-time three-dimensional echocardiography, as a new technology of ultrasonic diagnosis, is noninvasive, accurate and reliable in the diagnosis of ventricular aneurysm based on three- dimensional probe imaging technology. It can truly and accurately reflect the three-dimensional spatial structure of the cordis, three-dimensional spatial distribution and spatial adjacent relations, and accurately calculate parameters such as left ventricular volume and cardiac function through the extraction of ventricular volume. Especially for the calculation of left ventricular volume and cardiac function under pathological conditions, it is not limited by the geometric hypothesis of left ventricular morphology. Its measurements of left ventricular volume (LVV), ejection fraction (EF), and stroke volume (SV) have good correlation and consistency with MRI. Compared with the traditional two-dimensional echocardiography, it can more accurately and quantitatively evaluate the segmental systolic function and overall diastolic function of the left ventricular wall and can dynamically and intuitively observe the movement of the left ventricular walls. For the myocardium at the site of myocardial infarction, not only the thickness of the ventricular wall can be observed, but also the obvious movement abnormalities of the ventricular wall can be observed.

Real-time three-dimensional ultrasound has the advantages of short time consumption, rapid imaging, simple operation and good repeatability, which eliminate the influence of human factors in the two-dimensional reconstruction process and reduce the subjectivity and blindness of 2DE inspection. It can not only conduct a quasi-real-time dynamic observation of real three-dimensional spatial structure images of the heart in different phases, but also provide more accurate quantitative data and obtain new quantitative information and functional parameters, which has become the focus of current research and development. It is of epoch-making significance in the history of echocardiography and has injected new vitality into the diagnosis of cardiovascular diseases. It will certainly have a broad clinical application prospect in the diagnosis of cardiovascular disease, the prognosis of judging the disease, the therapeutic effect of follow-up drugs and so on.

Conclusion.

Applications of echocardiography have the advantages of short time consumption, rapid imaging, simple operation and good repeatability. To sum up, in the past, there was a blind spot in the measurement of right ventricular function. Now, the rise of applications of echocardiography have solved this defect for clinicians. As with any research, there are limitations to our study. The use of echocardiography, like any diagnostic test, is not without limitations and is subject to user error. However, with proper training and experience, echocardiography remains a valuable tool in the armamentarium of the cardiologist.

Overall, the applications of echocardiography have had a significant impact on the diagnosis, management, and prevention of cardiovascular disease. As our understanding of cardiac anatomy and physiology continues to evolve, echocardiography will undoubtedly remain an essential tool for clinicians and researchers alike.

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