Clinical utility of echocardiography in internal medicine: a narrative review

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ABSTRACT

Echocardiography has emerged as an invaluable tool in internal medicine, providing real-time, non-invasive evaluation of cardiac structure and function. Its clinical utility spans a wide range of applications, including the diagnosis and management of heart failure, valvular heart diseases, and cardiomyopathies, as well as systemic conditions like sepsis and chronic kidney disease. The ability to perform bedside echocardiography has made it particularly useful in critical care settings, allowing for rapid assessment of cardiac function in hemodynamically unstable patients. Echocardiography also plays a key role in guiding therapeutic interventions, from fluid management to valvular repair and replacement procedures. Despite its many advantages, echocardiography is not without limitations. Image quality may be compromised in patients with obesity, lung disease, or prior thoracic surgery, necessitating alternative imaging modalities like cardiac magnetic resonance imaging or computed tomography. Operator expertise is another critical factor influencing diagnostic accuracy, underscoring the importance of proper training. Recent advancements, including artificial intelligence integration and portable devices, are expected to further expand the role of echocardiography, making it more accessible in diverse clinical settings. This narrative review highlights the broad clinical utility of echocardiography in internal medicine, its challenges, and the future directions that promise to enhance its role in patient care.

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Key words: echocardiography, internal medicine, diagnostic imaging, cardiac diseases.

Contributions: all the authors made a substantial intellectual contribution, read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest: the authors declare that they have no competing interests, and all authors confirm accuracy.

Ethics approval and consent to participate: not applicable.

Patient consent for publication: not applicable.

Funding: none.

Availability of data and materials: data available from the corresponding author upon request.

Received: 20 September 2024.
Accepted: 20 September 2024.

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Licensee PAGEPress, Italy
Italian Journal of Medicine 2024; 18:1802
doi:10.4081/itjm.2024.1802

Introduction

Echocardiography has become an essential tool in modern internal medicine, providing real-time, non-invasive, and dynamic visualization of cardiac structure and function. Its use extends across a broad spectrum of clinical scenarios, from the evaluation of patients with known cardiovascular disease to those with systemic illnesses that may have cardiac implications. This review explores the clinical utility of echocardiography in internal medicine, highlighting its roles, advantages, limitations, and impact on patient care.

Role of echocardiography in diagnosing cardiac conditions

Echocardiography is indispensable in diagnosing a wide range of cardiac conditions. It is the cornerstone for evaluating heart valve function, assessing the size and shape of the heart, and estimating the ejection fraction, which is critical in diagnosing and managing heart failure. In patients with suspected valvular heart disease, echocardiography provides detailed information on the severity of stenosis or regurgitation, guiding treatment decisions such as medical management *versus* surgical intervention.[1] For patients presenting with dyspnea of unclear origin, echocardiography helps differentiate between cardiac and non-cardiac causes by assessing left ventricular function, detecting pericardial effusion, and evaluating for pulmonary hypertension. This is particularly important in internal medicine, where symptoms are often non-specific and can be

attributed to various organ systems.[2] In cases of suspected acute coronary syndrome, echocardiography can identify wall motion abnormalities, which may indicate myocardial ischemia or infarction. This imaging modality is also essential in diagnosing complications of myocardial infarction, such as ventricular septal defects, free wall rupture, and mitral regurgitation.[3] Additionally, echocardiography plays a critical role in the diagnosis of cardiomyopathies, whether they be dilated, hypertrophic, or restrictive, allowing for appropriate classification and management of these complex diseases.[4]

Utility in assessing systemic diseases with cardiac involvement

Beyond primary cardiac conditions, echocardiography is valuable in assessing systemic diseases that have cardiac involvement. For instance, in patients with chronic kidney disease (CKD), echocardiography is frequently used to monitor cardiac function, detect left ventricular hypertrophy, and assess fluid status, which can guide adjustments in dialysis and fluid management.[5] In systemic lupus erythematosus and other connective tissue diseases, echocardiography helps detect pericarditis, myocarditis, and valvular abnormalities, all of which are common in these conditions. Early detection of these complications allows for timely therapeutic interventions that can prevent further morbidity.[6] Similarly, in patients with diabetes mellitus, echocardiography is often used to assess diastolic dysfunction and detect subclinical cardiac disease, which is prevalent in this population.[7] Echocardiography is also crucial in the management of patients with sepsis, where cardiac dysfunction can be both a cause and a consequence of the systemic inflammatory response. By evaluating cardiac output and ventricular function, clinicians can make informed decisions about fluid resuscitation and the use of inotropes.[8] In patients with chronic obstructive pulmonary disease (COPD), echocardiography can help detect cor pulmonale, a condition of right heart failure secondary to lung disease. The identification of right ventricular dysfunction in these patients has significant implications for their management and prognosis.[9] Pulmonary hypertension, which can complicate COPD and other chronic lung conditions, is another area where echocardiography proves its utility. By estimating pulmonary artery pressures and assessing right ventricular function, echocardiography provides essential information for the diagnosis and management of pulmonary hypertension.[10] Echocardiography is also valuable in the evaluation of systemic conditions that may lead to cardiac amyloidosis. Amyloidosis is often underdiagnosed until it reaches an advanced stage, but echocardiography can detect characteristic findings such as increased left ventricular wall thickness and a granular sparkling appearance of the myocardium. These echocardiographic features, when correlated with clinical and laboratory findings, can prompt further diagnostic testing, including tissue biopsy or advanced imaging modalities, leading to early diagnosis and treatment.[11]

Guiding therapeutic interventions

One of the most significant advantages of echocardiography is its ability to guide therapeutic interventions in real time. In internal medicine, where management often involves balancing complex medical regimens, the ability to visualize the heart's response to treatment is invaluable. For example, in heart failure management, echocardiography is used to monitor response to medications such as diuretics, angiotensin-converting enzyme inhibitors, gliflozins, and β-blockers, and to assess the need for device therapy.[12] In patients with atrial fibrillation, echocardiography helps determine the presence of left atrial thrombus before cardioversion and guides the management of anticoagulation. It also aids in the decision-making process regarding the use of catheter ablation *versus* medical therapy.[13] Additionally, in patients with infective endocarditis, echocardiography is essential not only for diagnosis but also for monitoring the effectiveness of antibiotic therapy and deciding on the timing of surgical intervention if necessary.[14] Echocardiography is also used intraoperatively and postoperatively in various surgical settings, particularly in patients undergoing cardiac or major non-cardiac surgeries. It helps assess hemodynamic stability, guide fluid management, and detect complications such as myocardial ischemia, pericardial effusion, or valvular dysfunction that may arise during or after the procedure.[15] In addition, echocardiography can be instrumental in managing patients with pericardial diseases. In cases of pericardial effusion, echocardiography not only confirms the diagnosis but also guides therapeutic procedures such as pericardiocentesis by helping to localize the effusion and ensure safe needle insertion.[16] In constrictive pericarditis, echocardiography aids in differentiating it from restrictive cardiomyopathy by evaluating ventricular interdependence and respiratory variations in ventricular filling.[17]

Prognostic value in internal medicine

Echocardiography provides significant prognostic information across various clinical scenarios in internal medicine. For instance, in heart failure, parameters such as left ventricular ejection fraction, left atrial size, and the presence of right ventricular dysfunction are strong predictors of outcomes and guide therapeutic decisions.[18] In patients with pulmonary hypertension, echocardiography helps estimate pulmonary artery pressures and assess right ventricular function, which are crucial in determining prognosis and guiding therapy.[10] Similarly, in patients with COPD, echocardiography can detect cor pulmonale, which has important implications for management and prognosis.[9] Echocardiography also has prognostic value in acute settings. In patients with acute pulmonary embolism, the presence of right ventricular dysfunction on echocardiography is associated with an increased risk of adverse outcomes and may influence the decision to use thrombolytic therapy.[19] In sepsis, echocardiographic findings of reduced cardiac output or ventricular dysfunction can help identify patients at higher risk of mortality, prompting more aggressive management.[8] Moreover, echocardiography is pivotal in the long-term management of chronic cardiovascular conditions. In patients with valvular heart disease, serial echocardiographic monitoring allows for the timely identification of disease progression, which is crucial in determining the optimal timing for surgical intervention or the initiation of advanced therapies. For example, in aortic stenosis, the measurement of aortic valve area and gradient, combined with clinical symptoms, guides the decision on valve replacement.[20] In patients with hypertrophic cardiomyopathy, echocardiography is used not only for diagnosis but also for risk stratification. Features such as left ventricular outflow tract obstruction, the

presence of apical aneurysms, and the extent of left ventricular hypertrophy provide essential prognostic information and influence therapeutic strategies, including the consideration for implantable cardioverter-defibrillators.[4]

Echocardiography in special populations

In the field of internal medicine, echocardiography is particularly useful in special populations such as the elderly, patients with CKD, and those undergoing chemotherapy. In the elderly, echocardiography is essential for assessing conditions like diastolic dysfunction, which is prevalent in this population and can contribute to heart failure with preserved ejection fraction. The identification of diastolic dysfunction and elevated filling pressures through echocardiographic parameters can guide treatment and management in these patients.[21] In patients with CKD, echocardiography plays a crucial role in evaluating cardiovascular risk. CKD patients often develop left ventricular hypertrophy, fluid overload, and coronary artery disease, all of which can be detected and monitored through echocardiography. Furthermore, echocardiography can assess the cardiovascular impact of anemia and hypertension, common comorbidities in CKD, helping tailor individual treatment plans.[22] For patients undergoing chemotherapy, particularly with agents known to cause cardiotoxicity (*e.g.*, anthracyclines), echocardiography is the primary tool for monitoring cardiac function. Regular echocardiographic evaluations allow for the early detection of subclinical myocardial damage, enabling timely interventions to prevent the progression to heart failure; strain imaging, a more sensitive echocardiographic modality, is increasingly used in this context to detect early myocardial deformation before changes in ejection fraction become apparent.[23]

Limitations and challenges

Despite its widespread use and many advantages, echocardiography has limitations and challenges that must be considered. One of the primary limitations is its operator dependency. The accuracy of the images and the interpretation of the findings can vary significantly depending on the skill and experience of the operator.[24] This variability can lead to differences in diagnosis and management, particularly in complex cases. Another challenge is the limited acoustic window in certain patients, such as those with obesity, chronic lung disease, or previous thoracic surgeries, which can impair image quality and limit the diagnostic utility of echocardiography. In such cases, alternative imaging modalities, such as cardiac magnetic resonance imaging (MRI) or computed tomography (CT), may be necessary to provide complementary information. Additionally, while echocardiography provides excellent real-time images, it is sometimes limited in its ability to quantify certain parameters accurately, such as right ventricular volumes and function, due to the complex geometry of the right ventricle. Advanced techniques like 3D echocardiography and speckle-tracking echocardiography have been developed to address some of these limitations, but they require specialized equipment and expertise that may not be available in all settings.[25] Moreover, the interpretation of certain echocardiographic findings, such as diastolic dysfunction, can be complex and may require integration with clinical data and other imaging modalities for accurate diagnosis; this complexity underscores the importance of comprehensive training and ongoing education for clinicians who use echocardiography in their practice.[24] Lastly, while echocardiography is a powerful tool, there is a risk of overreliance on imaging findings, potentially leading to overtreatment or unnecessary interventions. It is essential for clinicians to balance the information obtained from echocardiography with other clinical data and to avoid making decisions based solely on imaging results.[26]

Future directions in echocardiography

The field of echocardiography is continually evolving, with ongoing research and technological advancements aimed at improving its diagnostic and prognostic capabilities. One promising area of development is the use of artificial intelligence (AI) in echocardiography. AI algorithms are being developed to assist in image acquisition, interpretation, and quantification, potentially reducing operator dependency and improving the accuracy and reproducibility of echocardiographic assessments.[27] Another area of innovation is the integration of echocardiography with other imaging modalities, such as cardiac MRI and CT, to provide a more comprehensive assessment of cardiac structure and function. This multimodality approach can offer complementary information that enhances diagnostic accuracy and informs treatment decisions.[28] Point-of-care echocardiography (POCUS) is also gaining popularity in internal medicine, allowing clinicians to perform focused echocardiographic examinations at the bedside. POCUS can provide immediate information in acute settings, such as evaluating a patient with hypotension or shortness of breath, and can help guide initial management.[29] As handheld ultrasound devices become more affordable and widely available, the use of POCUS is expected to expand, further integrating echocardiography into routine internal medicine practice. Moreover, advances in portable and handheld echocardiography devices are making this technology more accessible in various clinical settings, including remote and resource-limited environments. These portable devices, combined with telemedicine capabilities, have the potential to extend the benefits of echocardiography to a broader patient population, improving the early detection and management of cardiac conditions.[30]

Conclusions

Echocardiography has become an indispensable tool in internal medicine, offering a non-invasive, real-time, and dynamic assessment of cardiac structure and function. Its utility extends across a wide range of clinical scenarios, from diagnosing primary cardiac conditions to assessing systemic diseases with cardiac involvement. Echocardiography guides therapeutic interventions, provides valuable prognostic information, and is particularly useful in special populations such as the elderly and patients with CKD. However, the use of echocardiography is not without challenges, including operator dependency and limitations in image quality. Ongoing advancements in technology, including AI and portable devices, are poised to address some of these challenges and further enhance the utility of echocardiography in internal medicine. As the field continues to evolve, it is crucial for cli-

nicians to stay updated on the latest developments and to integrate echocardiography into their clinical practice in a way that maximizes its benefits for patient care. The future of echocardiography in internal medicine looks promising, with the potential to improve diagnostic accuracy, guide treatment, and ultimately enhance patient outcomes.

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