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Mini Review Article

Telehealth and Point-of-Care Ultrasound in Cardiology: A Mini Review

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Abstract

Cardiovascular diseases (CVDs) remain the leading cause of mortality and morbidity worldwide (1). Timely diagnosis, monitoring and management of cardiac conditions are essential to reduce the burden of CVDs. Recent advancements in telehealth and point-of-care ultrasound (POCUS) have reshaped cardiac care by offering new diagnostic and therapeutic opportunities outside traditional clinical environments (2,3). Telehealth enables remote patient evaluation, follow-up, and management, while POCUS provides immediate cardiac imaging at the bedside or in remote settings (2,4). Their combination, termed tele-cardiac ultrasound or tele-echocardiography, has shown promising results in emergency departments, intensive care units, prehospital settings, outpatient cardiology and rural healthcare delivery (3,5). This mini- review summarizes the integration, applications, advantages, challenges and future perspectives of telehealth and POCUS in cardiology, with a focus on improving access, patient outcomes, and health system resilience.

Introduction

Cardiovascular diseases contribute to approximately 18 million deaths annually worldwide, representing a major global health challenge (1). Early detection and management of cardiac disorders, including heart failure, ischemic heart disease, arrhythmias and valvular heart diseases, are crucial to improving patient outcomes. However, access to specialized cardiac care remains limited in many regions due to geographical, infrastructural, and socioeconomic barriers. POCUS has emerged as a transformative tool that enables clinicians to perform focused cardiac ultrasound (FOCUS) directly at the bedside, facilitating rapid diagnostic and management decisions (7). Telehealth, encompassing video consultations, remote monitoring and store-and-forward systems, has extended the reach of cardiologists to patients who otherwise lack timely access (4). When combined, telehealth and cardiac POCUS provide real-time diagnostic and consultative capabilities to frontline providers, even in settings without on-site cardiology expertise (3,5) [Image 1.]. The COVID-19 pandemic has accelerated the adoption of both technologies and demonstrated their utility in maintaining continuity of care during health crises (2,9).

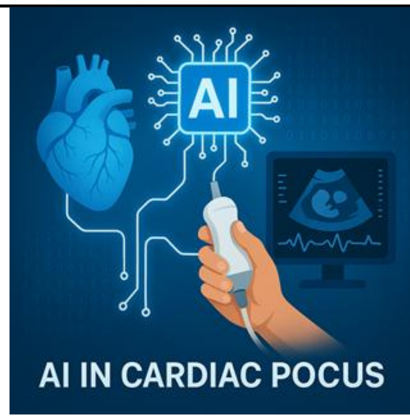

Image 1. The amalgamation of AI in POCUS implementation in Cardiology. The image has been created by ChatGPT tool.

Overview of Telehealth in Cardiology

Telehealth is now firmly embedded in cardiology practice. Remote consultations, virtual follow-ups, and digital transmission of diagnostic data have become routine, particularly for managing chronic cardiovascular conditions such as hypertension, heart failure, and atrial fibrillation (8).

Applications of Telehealth in Cardiology:

Telehealth applications have been increasingly integrated into routine cardiology practice, encompassing a broad range of interventions. Commonly reported modalities include virtual outpatient cardiology clinics, remote heart failure management programs, tele-rehabilitation and virtual cardiac rehabilitation, remote electrocardiogram (ECG) and Holter monitoring, home-based blood pressure and heart rate monitoring, and tele-consultations for acute chest pain evaluation. Several studies have demonstrated that these interventions improve access to specialist care, facilitate early identification of clinical deterioration, and may contribute to improved clinical outcomes, particularly in populations with limited access to healthcare facilities. Moreover, remote monitoring tools such as home-based ECG, blood pressure, and heart rate devices have shown potential in optimizing guideline-directed medical therapy and reducing hospitalizations, especially among patients with heart failure. However, the heterogeneity of study designs and outcome measures across the available literature highlights the need for further high-quality randomized controlled trials to confirm the long-term effectiveness and cost-effectiveness of telehealth interventions in cardiology. Telehealth has reduced barriers to accessing specialist cardiology services, minimized hospital visits and allowed for better management of heart failure and post-myocardial infarction patients. Furthermore, it has been shown to improve medication adherence and patient satisfaction (8).

Fundamentals of Cardiac POCUS

POCUS is defined by its targeted, problem-oriented nature and is increasingly used for cardiac assessment, especially by non-cardiologist clinicians (7). FOCUS includes limited cardiac imaging tailored to answer specific clinical questions such as:

- Is there a pericardial/pleural effusion?
- Is left ventricular function severely reduced?
- Is there evidence of right heart strain?
- Is there a significant volume overload?

Unlike comprehensive transthoracic echocardiography (TTE) performed by cardiologists or sonographers, FOCUS is performed rapidly to guide immediate clinical decision-making (4). Emergency physicians, intensivists, internists, nephrologists and even general practitioners can be trained to perform FOCUS (2).

Handheld ultrasound devices have revolutionized bedside cardiac imaging. These devices, combined with wireless connectivity, allow image transmission for remote interpretation, forming the backbone of tele-cardiac ultrasound (5). Their miniaturized size is inversely proportional to their applications and may diminish clinical barriers or inertia.

Telehealth and POCUS Integration in Cardiology (Tele-echocardiography)

The integration of POCUS into telehealth workflows enables a practical, scalable, and cost-effective model for cardiac imaging, especially in underserved or remote settings (3).

Common Tele-echocardiography Models:

The integration of point-of-care ultrasound (POCUS) into telehealth platforms is rapidly transforming cardiac imaging in both acute and non-acute settings. Practical approaches such as live-streamed scans, store-and-forward techniques, remote-guided scanning, and AI-augmented POCUS are increasingly being used to support real-time decision-making. These tools enable rapid bedside cardiac assessments, often without the need to wait for formal echocardiography, which can be particularly valuable in emergency departments, intensive care units, and remote settings. Beyond improving diagnostic speed, tele-POCUS has the potential to enhance image quality, standardize assessments through AI assistance and expand access to expert interpretation regardless of geographical limitations. Early evidence suggests that these strategies may contribute to faster diagnosis, timely initiation of therapy, and ultimately better patient outcomes. Nevertheless, optimal implementation still requires clear protocols, training pathways, and further validation in larger, real-world clinical studies.

Clinical Applications in Cardiology

- **Ejection fraction**: POCUS can rapidly estimate the systolic function of the left ventricle by eye-walling and adjuct to diagnosis. EF is sinequanone parameter at the assessent of patients at a jeopardized clinical status but it carries a rather significant inter-obserever varaiblity. When combined with AI technology the accuracy may augment. İn this multicenter prospective observation study in Japan, AI-POCUS detected reduced LVEF [< 50%] with a sensitivity of 85% (95% confidence interval 76%–91%) and specificity of 81% (71%–89%). [11]
- **Heart Failure**: POCUS can assess left ventricular function, estimate central venous pressure via inferior vena cava (IVC) diameter, and detect pleural effusions or B-lines (7). Telehealth-based heart failure clinics integrate POCUS to guide diuretic adjustments and early intervention, reducing readmissions (8).
- **Valvular Heart Disease**: POCUS can detect gross valvular abnormalities such as severe aortic stenosis or mitral regurgitation. In remote areas, tele-echocardiography facilitates screening for valvular lesions, allowing for appropriate triaging and timely referral (3).
- **Pericardial Diseases**: FOCUS is highly sensitive for detecting pericardial effusions and tamponade physiology (7). Telehealth allows cardiologists to remotely confirm or rule out tamponade, guiding emergent pericardiocentesis (2).
- **Acute Coronary Syndrome**: In patients with chest pain, bedside FOCUS helps identify complications such as left ventricular dysfunction, regional wall motion abnormalities, or mechanical complications of myocardial infarction (5). Remote cardiologist consultation using tele-ultrasound enhances diagnostic accuracy (3).
- **Aortic syndromes**: FOCUS may provide essential measurement of the aorta diameter (ascending, aortic arch, abdominal) and reveal critical aneurysms or flaps. This application is mandatory at the differential diagnosis of chest pain and facilitates appropriate therapy [antithrombotic therapy is contraindicated in aortic syndromes] (10).
- **Pulmonary Embolism and Right Heart Strain**: POCUS can demonstrate right ventricular dilatation and dysfunction, indirect markers of pulmonary embolism (9). Remote expert input increases diagnostic confidence, helping clinicians initiate appropriate treatment.
- **Miscellaneous**: FOCUS may reveal masses into cardiac cavities like thrombus or myxomas and guide further diagnostic sequel in patients with neurologic or other embolic symptoms.
- **Prehospital and Rural Cardiology**: EMS and rural clinicians can perform FOCUS with remote cardiology support, enabling early triage decisions, faster activation of cardiac catheterization labs, or

initiation of thrombolytic therapy when PCI is not immediately available (5).

The integration of telehealth with point-of-care ultrasound (POCUS) in cardiology offers several potential advantages. These include facilitating timely diagnosis, expanding access to cardiology expertise, reducing unnecessary patient transfers, improving clinical outcomes, and demonstrating cost-effectiveness across various healthcare settings. Additionally, telehealth-POCUS applications provide significant educational benefits by supporting clinician training and skill development through remote guidance and feedback. However, several limitations and challenges remain. The technique is highly operator-dependent, and image quality may vary substantially depending on user experience and technical conditions. Connectivity issues, especially in resource-limited or rural settings, may further hinder effective implementation. Moreover, the successful adoption of telehealth-POCUS requires structured training programs and raises concerns regarding legal, regulatory, and data privacy issues that are yet to be fully addressed in routine practice. These challenges underscore the need for standardized protocols and further research to optimize the safe and effective use of telehealth-POCUS in cardiology. [Table 1.]

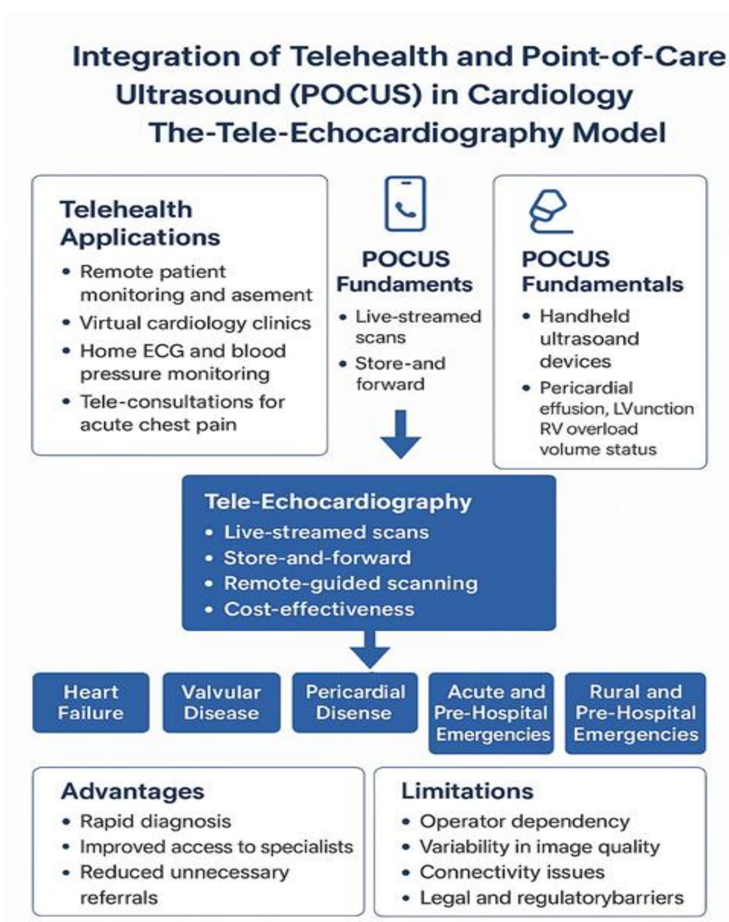

Table 1. The Tele – Echocardiography model. Implications and pitfalls.

Recent technological innovations have significantly enhanced the integration of telehealth and point-of-care ultrasound (POCUS) in cardiology. AI-assisted POCUS has emerged as a promising tool to improve image acquisition, interpretation, and diagnostic accuracy, particularly for non-expert users. The widespread adoption of handheld ultrasound devices has facilitated bedside imaging and expanded the use of POCUS beyond traditional hospital settings. Additionally, the implementation of high-speed 5G connectivity has improved the quality and reliability of real-time image transmission, enabling effective remote supervision and tele-guidance. Furthermore, virtual reality (VR) and augmented reality (AR) technologies are being explored as innovative methods for remote guidance and clinician training, potentially enhancing the standardization and effectiveness of telehealth-POCUS procedures. These advancements collectively contribute to improving the feasibility, scalability, and clinical impact of telehealth applications in cardiolog

Future Directions

The role of telehealth and point-of-care ultrasound (POCUS) in cardiology is expected to expand further in the coming years, driven by continuous technological advancements and the growing demand for accessible cardiovascular care. The development of AI-driven automated image interpretation and reporting systems is anticipated to significantly reduce operator dependency, standardize diagnostic accuracy, and streamline clinical workflows. Additionally, advancements in connectivity, particularly the global rollout of 5G and other high-speed networks, will enhance the feasibility of real-time remote guidance and supervision, even in geographically isolated regions. Importantly, tele-ultrasound is increasingly being recognized as a strategic tool by global health programs aiming to address disparities in cardiovascular care, especially in low- and middle-income countries (LMICs) where access to specialist services remains limited[Image 2.].Future efforts should focus on developing standardized training programs, validating AI-assisted applications in diverse clinical settings, and addressing the regulatory, ethical, and infrastructural challenges to ensure the sustainable and equitable integration of telehealth-POCUS into routine cardiology practice.

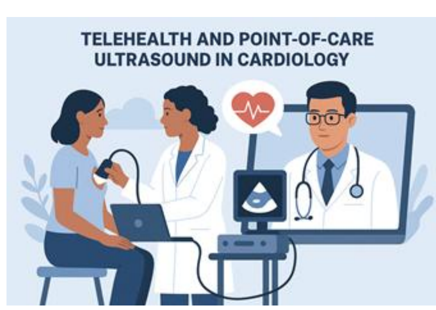

Image 2. Telehealth may diminish the gap between unprivileged or remote populations and appropriate

therapy. The image has been created by ChatGPT tool.

Conclusions

The integration of telehealth and point-of-care ultrasound (POCUS) has unlocked new opportunities to enhance the quality, accessibility, and efficiency of cardiology care globally. By enabling timely diagnosis, facilitating remote expert consultations, and extending diagnostic capabilities to resource-limited and underserved settings, this synergy has the potential to address significant gaps in cardiovascular care delivery. The growing availability of advanced technologies, such as AI-assisted POCUS, handheld ultrasound devices, and high-speed connectivity, further supports the expansion and scalability of telehealth-POCUS applications. Moreover, as training programs and clinical protocols continue to evolve, both the technical proficiency of clinicians and the standardization of practice are expected to improve. Nevertheless, several challenges, including operator dependency, connectivity issues, and regulatory considerations, must be systematically addressed to fully realize its potential. Looking forward, the integration of telehealth and POCUS, supported by ongoing technological advancements and structured clinician education, holds substantial promise to improve patient outcomes and reduce healthcare disparities, particularly in populations with limited access to specialized cardiology services.

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