Brief Communication

# Correlation of Telemedicine-guided POCUS Echocardiography and In Situ Data: Pilot Study in a Remote Area in Brazil

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## Abstract

Cardiovascular diseases remain the leading cause of mortality in Brazil. Nevertheless, a significant portion of the Brazilian population still faces challenges in accessing specialized care and undergoing complementary exams, especially in remote areas. Currently, data transmission and remote specialized assessment are possible, but obtaining echocardiographic images still relies on a trained professional on-site. This pilot study aimed to assess the feasibility of Point-of-Care Ultrasound (POCUS) tele-echocardiography administered by a general physician with specialist guidance to improve accessibility to cardiovascular exams. Ten patients (mean age was 58.6±8 years, 50% female) from the North region participated, undergoing remote-guided tests using Philips Lumify™ ultrasound and Facetime for transmission. These patients had recent official echocardiographic exams. As part of the POCUS examination, seven echocardiographic views were obtained — parasternal long axis, parasternal short axis (PSAX), apical four chambers (A4C), apical five chambers (A5C), apical two chambers (A2C), subcostal (SC), and suprasternal (SSN). The procedure included linear measurements of cardiac chambers, and valve analysis was performed using color flow. The on-site examinations were carried out by a general physician who underwent brief training prior to the official exams. Despite encountering technical challenges, the study demonstrated the viability of acquiring echocardiographic images. Overall agreement in examination results was observed, except for left ventricular segmental contractility in two cases and the systolic diameter of the left ventricle. The approach, though performed by untrained professionals, showed promise in screening cardiovascular diseases in remote locations, focusing on ventricular function and valvular diseases. Nevertheless, further research is necessary to improve the quality of this process.

## Keywords

Echocardiography; Telemedicine; Ultrasonography; Telediagnostics; Telecardiology

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## Introduction

Performing echocardiography is a challenging task in areas that are remote and have a low human development index.[1] Although data transmission is currently available and there is ample evidence of remote specialized evaluation, it depends on a professional trained *in loco* to obtain the echocardiographic views.[2] The use of artificial intelligence is still in the development stage and requires more scientific evidence.[3]

In recent years, tele-echocardiography has expanded all over the world, involving experimental studies with non-cardiologist physicians, non-physicians, and even remotely operated robotic devices, combined with remote interpretation by cardiologist echocardiographers.[4]

Handheld imaging platforms and remote interpretation have introduced these developments to the realm of echocardiography. The increasing accessibility of mobile computers and handheld imaging devices opens up new avenues for delivering and optimizing cardiovascular healthcare.[5] Various types of handheld ultrasounds with differing capabilities are available; a laptop-based system covers almost every 2D echocardiographic application, whereas a pocket-size ultrasound may not have full-scale color-flow and spectral Doppler capabilities. POCUS has demonstrated good accuracy. For instance, in a study by Abe et al., which involved 130 patients with aortic stenosis, pocket ultrasound successfully differentiated moderate-to-severe aortic stenosis with a sensitivity of 84% and specificity of 90%, even without quantitative Doppler information.[6]

In Brazil, there is an ongoing program for screening congenital heart diseases in the northeastern region of the country, where telemedicine and tele-echocardiography are utilized for early diagnosis and patient monitoring.[7]

While tele-echocardiography has proven useful in detecting cardiac abnormalities, it still lacks robust evidence, particularly concerning image quality compared to traditional echocardiography. Furthermore, its implementation in remote areas necessitates discussions on digital infrastructure, cost-effectiveness, regulation, and legal challenges.[5]

The feasibility of untrained medical professionals obtaining POCUS echocardiography data using a handheld device, guided synchronously by a mobile device under the supervision of an echocardiographer, is still under investigation.[8]

This pilot study aims to assess the feasibility and correlation of echocardiography data obtained in person versus those guided by telemedicine, conducted by untrained general practitioners using simple devices.

## Materials and methods

This pilot prospective unicentric study analyzed ten consecutive patients in the North Region of Brazil who were part of the specialized medical assistance program through the telemedicine health system development program (PROADI, in the Portuguese acronym) by the Ministry of Health, Brazil. The study was performed at Almeirim in Pará, Brazil, a remote city that could be reached mainly through water transport, which comprised the Telemedicine Center and an echocardiographer.

The inclusion criteria for the participants comprised age ≥ 18 years old, returning for the medical telemedicine appointment and bringing an echocardiography performed *in loco*. The exclusion criteria were incomplete echocardiographic data. *In situ* echocardiograms were performed by different echocardiographers.

Data collection took place from June to July 2023. This study was approved by the local institutional review board under the registration of the name TeleECO. All data can be accessed from the institutional digital records.

All remote-guided tests were performed using a portable Philips Lumify® ultrasound (Figure 1). Seven echocardiographic views were defined to be performed on all patients: parasternal long axis (PLAX), PSAX, A4C, A5C, A2C, SC, and SSN.

The professional who conducted the examinations locally is a general practitioner from the local basic health unit. Two pre-exam meetings were held to train the general practitioner, with each meeting including training on performing a complete examination.

The exams were transmitted via the Facetime platform.

It was a POCUS approach, so it was obtained linear measurements of cardiac chambers (septum, posterior wall, aortic root, ascending aorta, left atrium, systolic diameter of the left ventricle and diastolic diameter of the left ventricle) taken in the parasternal long axis view (APLAX), and measurements of the right ventricle were taken in the A4C view. Valve analysis was conducted using color flow, as the continuous Doppler function was not available on the portable device. Free tracing for the assessment of cardiac chamber volumes, such as the left atrium, and for determining ventricular function using the Simpson method was also not feasible.

When there was left ventricular dysfunction, the ejection fraction was estimated by the echocardiography specialist who was guiding the examination remotely. The time taken to perform each exam was recorded. The IBM-SPSS for Windows version 22.0 software was used, and the statistics were descriptive.

## Results

The first ten consecutive patients screened were included in the study. Seven patients with cardiovascular risk factors had

**Figure 1 –** *Portable Philips Lumify® ultrasound used to perform the exams.*

in situ exams requested to investigate end-organ damage, two for risk stratification in patients with chronic coronary artery disease, and one for evaluating mitral biological prosthesis. The mean age of the patients was 58.6±8 years, and 50% were female.

The mean time taken to perform the POCUS echocardiography exam was 23.1 minutes. All proposed cardiac seven views were obtained, some with window limitation due to patient biotype. We had imaging limitations in one patient with obesity in the SC and SSN windows. Guidance and image interpretation were feasible through mobile screen calls. The results of the main continuous variables for each patient are shown in Figure 2, and examples of images interpreted by the cell phone screen are shown in Figure 3. Regarding regional wall motion abnormalities, eight patients showed conformity between tests. In these two cases, remote evaluation identified segmental abnormalities that were not observed previously, but both patients underwent cardiac catheterization immediately after the virtual encounter, and the clinical context of the procedure may explain the disparity in results. Concerning valvular heart disease, there was agreement in nine exams (five with no regurgitation jets and four with mild mitral regurgitation jets). However, in one test, the remote assessment noted mild mitral regurgitation that had not been reported earlier.

The echocardiographs performed *in situ* were done four to twelve months prior to the remotely guided test. One of the patients had a biological mitral prosthesis, and its evaluation was limited due to the absence of continuous Doppler in the device. In general, the assessment of cardiac function through ejection fraction was reasonably equivalent between the tests.

## Discussion

Echocardiogram is a simple and non-invasive diagnostic test that is difficult to access in remote places, and the main factors that contribute to this are the availability of the device and a trained professional. Although specialized cardiological

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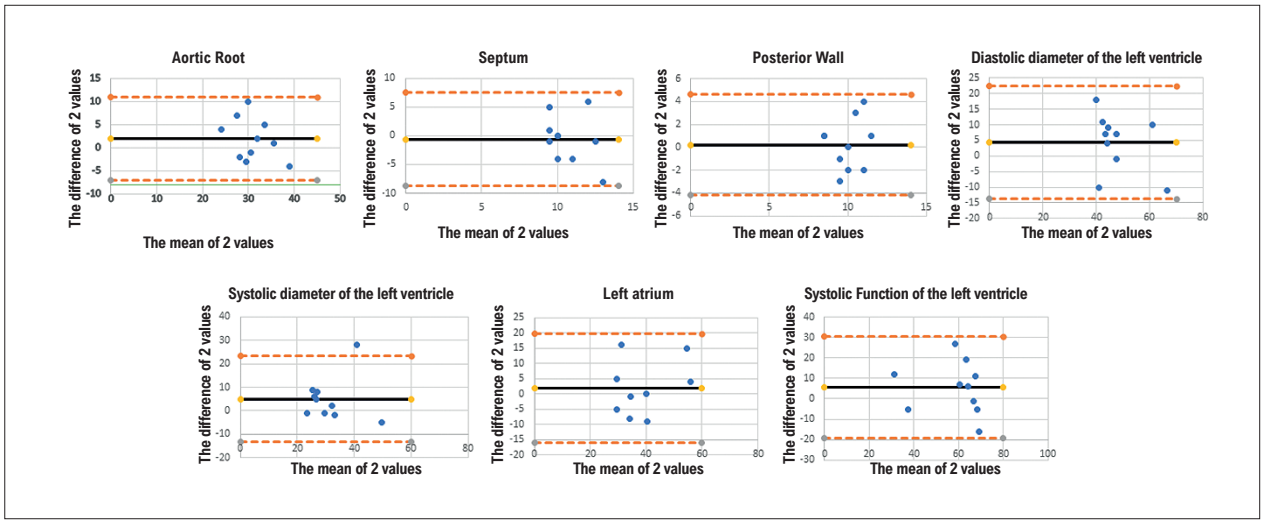


**Figure 2 –** *Based on the analysis of the Bland-Altman plots obtained from linear measurements, it can be observed that, despite a difference in the mean of the measurements, most elements showed agreement between the measurements, remaining within the confidence interval. The exception was the systolic diameter of the left ventricle, where one measurement fell outside the interval.*

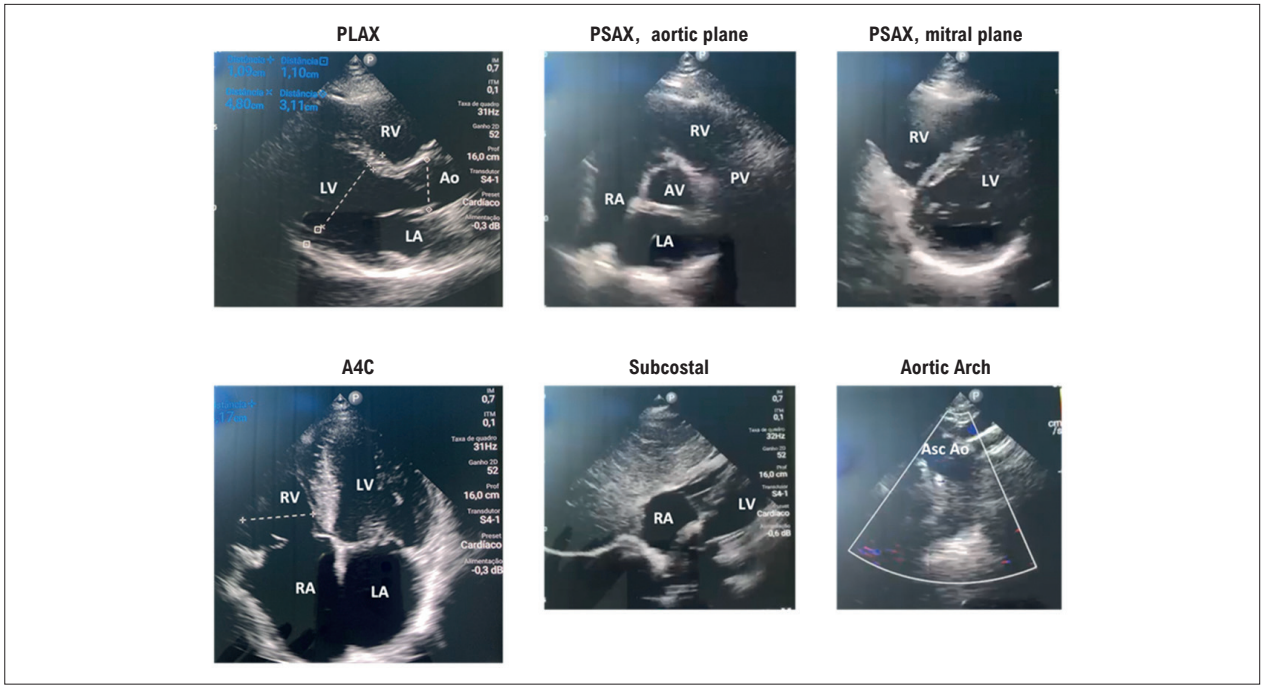


**Figure 3 –** *Six basic echocardiography views analyzed remotely by cell phone screen. PLAX: parasternal long axis; PSAX: parasternal short axis; A4C: apical four chambers; SC: subcostal.*

care provided virtually is possible, it is focused on clinical reasoning in teleconsultation, and the problem of carrying out complementary exams is still worrying.

Tele-echocardiography is usually based on images obtained by non-medical professionals with an asynchronous echocardiographer interpretation.[9] A Brazilian study with this methodology included more than 1,000 patients. It showed a high correlation for detecting cardiovascular alterations between the tests, but led to the overestimation of regurgitation jets, ventricular dysfunction, and ventricular hypertrophy.[10]

Our study had an untrained general practitioner performing echocardiographic views with a portable device. All remote-guided tests were performed using a portable Philips Lumify® ultrasound. Seven echocardiographic views were defined to be performed on all patients: PLAX, PSAX, A4C, A5C, A2C, SC, and SSN. The professional who conducted the examinations locally is a general practitioner from the local

basic health unit. Two pre-exam meetings were held to train the general practitioner, with each meeting including training on performing a complete examination.

We faced some technical difficulties during the conduction of the guided test. The first pertains to the necessity of a third person who would be responsible for recording the real-time execution of the test for the specialist to guide hand movements and probe angulation to improve the quality of the acquired image. The second lies in the examination's guidance, particularly in the fine movements required to optimize the image quality. Despite these challenges, all patients obtained results that could be analyzed and compared to the official *in situ* echocardiogram.

There were some discrepancies in the linear measurements obtained, especially in the dimensions of the systolic diameter of the left ventricle, besides the septum and posterior wall, which resulted in an overestimation of the hypertrophy and can be attributed to the examination executor's lack of experience.

As the examinations progressed, the time required for their execution decreased. The mean time was 23 minutes, which is a feasible timeframe for integrating this examination into primary care services.

Lastly, it's important to highlight that this pilot study presents certain limitations. The first relates to the portable Ultrasound device. While the promises of POCUS are substantial, one of the major concerns is standardizing the quality of scanning and interpretation, in addition to its limited capabilities in terms of image quality and applications like pulsed-wave Doppler. Due to its availability, POCUS can be more easily utilized than standard echocardiography, and the image quality and interpretation issues can be addressed by having a specialist during real-time exams.

The second involves the inclusion of consecutive patients without any regular clinical follow-up. Furthermore, using different echocardiography devices to conduct the *in-situ* tests may lead to variations in the quality of the obtained images.

## Conclusion

Timely telemedicine-guided echocardiography performed by a generalist professional appears to be feasible for screening cardiovascular diseases in remote locations, especially for the assessment of ventricular function and screening for valvular diseases. Future research must be done to address the quality development of this task.

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## Author Contributions

Conception and design of the research: Rompkoski J, Accorsi TAD, Freitas CB, Moreira FT, Kohler KF, Lima KA, Morbeck RA, Pedrotti CHS; acquisition of data: Rompkoski J, Amaral BDR, Freitas CB, Morbeck RA; analysis and interpretation of the data, statistical analysis and writing of the manuscript: Rompkoski J, Accorsi TAD; critical revision of the manuscript for intellectual content: Accorsi TAD, Moreira FT, Kohler KF, Lima KA, Pedrotti CHS; study supervision: Pedrotti CHS.

### Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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There were no external funding sources for this study.

### Study Association

This study is not associated with any thesis or dissertation work.

### Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Hospital Israelita Albert Enstein under the protocol number 63709222.0.000.0071/5.934.573. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

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