Editorial

Mitral Valve Area Quantification Using Digital Image Processing: Is That Feasible?

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Regarding article "Automatic Measurement of Mitral Valve Based on Echocardiogram Using Digital Image Processing"

Echocardiography, since its initial descriptions in the 1950s, has evolved every decade with the incorporation of numerous new techniques, enabling structural cardiac analysis from multiple planes of spatial observation in real time. This occurred with the advent of nanotechnology, digital technology, application of modifiable algorithms based on the concept of machine learning and deep learning through the development of artificial intelligence (AI).[1-6] The use of AI is an ever-increasing reality in medicine as a whole, mainly in operator-dependent imaging areas, such as ultrasonography imaging.

In the concept of analyzing the confluence of a very large number of pieces of information (e.g. radiomics, metabolomics, proteomics) for the formation of data clusters with the aim of integrated patient observation, the formation of precision medicine, AI is used in a rational and organized way. The use of AI allows faster, more balanced and homogeneous observation of inputs, in the sense of minimizing inter and intraobserver errors.[1-6] In the specific echocardiographic evaluation, the use of AI presents a very wide range of applications, having been used for the acquisition of echocardiographic information for the quantification of left ventricular volumes and mass, analysis of biventricular systolic function, segmentation and qualification of the cusps, annulus and mitral valve apparatus, analysis of hypertrophic phenocopy (athletes, patients with hypertrophic cardiomyopathy), to predict the outcome of percutaneous hemodynamic procedures (e.g.: mitraclip).[1] We are currently working on a project in association with the University of Chicago for AI analysis of patients affected by transthyretin cardiac amyloidosis.

Regrettably, rheumatic disease remains, in the 2020s, a pathology of great epidemiological expression, especially in underdeveloped and developing countries.[7] Therefore, it seems highly appropriate and of special interest the echocardiographic analysis using AI and its various algorithms for interpreting patients suffering from rheumatic disease. Rheumatic disease is the most prevalent etiology of mitral valve stenosis, with mitral stenosis being the most expressive chronic lesion of rheumatic cardiac involvement.[7,8] Echocardiography is an essential diagnostic tool in the recognition and determination of the extent of cardiac involvement in rheumatic disease, especially in mitral valve dysfunction, by demonstrating typical findings such as reduced mobility due to leaflet thickening, commissural fusion, involvement of the subvalvular apparatus (shortening, thickening and fusion of the chordae tendineae) and valve and annulus calcification.[7-9] The progressive reduction of the valve area is accompanied by a gradual increase in left atrial pressure, pulmonary venous pressure and the onset of more common symptoms such as dyspnea.[7-9] The grading of mitral stenosis requires careful valve morphofunctional evaluation, as well as an accurate analysis of associated pathologies due to the implications in the therapeutic decision and the choice from different types of intervention (percutaneous or surgical approach in its multiple possibilities).[7-9]

Echocardiography is the first-line imaging technique for analyzing the mitral valve, offering numerous advantages over other analysis techniques (real-time analysis, devoid of radiation, based on three-dimensional projections, low cost, widely available); however, it has limitations, such as the great dependence on the quality of the acquired image, dependence on the cardiologist's experience during the acquisition and interpretation of images, especially in the three-dimensional study, which requires additional training and experience, for better multiplanar reconstruction of cardiac structures. Real-time three-dimensional echocardiography shows the leaflets in multiple planes, providing a more accurate identification of the most anatomical opening of the mitral valve.[7-9] Evaluation of valve segmentation, important in minimally invasive structural cardiac intervention, showed great progress in recent years, due to the applicability of AI to cardiovascular imaging tests.[4,9] This AI analysis of the mitral valve apparatus has evolved rapidly over the last few years, from the analysis that required many steps for its final elaboration to the semiautomatic, rapid and very expressive analysis of the mitral valve anatomy.[4,9] We are currently working on a project for the rapid semiquantitative analysis of the surgical results of patients with mitral valve disease due to fibroelastic etiology and valve prolapse, with pre and post-operative analysis after double teflon repair. This analysis shows the observation of more than 30 elements that constitute the mitral valve apparatus.

Keywords

Artificial intelligence; automated diagnosis; algorithm; echocardiography; mitral valve.

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AI technology has the potential to optimize and revolutionize the practice of echocardiography, creating opportunities for standardization, improving accuracy and efficiency in cardiovascular imaging laboratories.[1-6] In recognition of this growing influence in echocardiography laboratories, Professor Vera Rigolin, from the Northwestern Memorial Hospital, Chicago, USA, introduced the concept of the four pillars of AI, namely: education, image acquisition, analysis and integration with clinical data.[5] These actions tend to minimize intra- and interobserver variability, inherent in the echocardiographic method, through the creation of protocols for the acquisition and analysis of images to quantify left ventricular ejection fraction, myocardial strain and grading valve lesion severity, among other application possibilities.[5]

AI-based digital image processing (DIP), a method proposed by Barros Filho et al.,[10] published in this issue of Arquivos Brasileiros de Cardiologia: Imagem Cardiovascular, has the purpose of improving the visual information of the mitral valve for analysis, automating the determination of the valve area by planimetry and transmitting and storing this information. Usually, image processing after acquisition tends to be hard work, requiring specific training and knowledge. The proposed DIP may eventually have a great clinical impact by minimizing this difficulty by using an easy, fast and intuitive language system with adequate reproducibility, with the potential to reduce human distraction and fatigue, inherent in complex and prolonged work, limiting intra- and inter-observer variability and assisting the interpretation of multiple and complex data.

Therefore, we recommend reading the article "Automatic Mitral Valve Measurement Based on Echocardiography Using Digital Image Processing,"[10] by Barros Filho et al., congratulating the group of researchers for the excellence of the investigation.

References

1. Daminello E, Vieira PPAC, Fischer CH, Vieira MLC. Aplicação da Inteligência Artificial em Imagem Cardiovascular: em Ecocardiografia. Rev Soc Cardiol Estado de São Paulo. 2021;31(4):388-93. doi: 10.29381/0103-8559/2022320139-44.

2. Narang A, Bae R, Hong H, Thomas Y, Surette S, Cadieu C, et al. Utility of a Deep-Learning Algorithm to Guide Novices to Acquire Echocardiograms for Limited Diagnostic Use. JAMA Cardiol. 2021;6(6):624-32. doi: 10.1001/jamacardio.2021.0185.

3. Chao CJ, Kato N, Scott CG, Lopez-Jimenez F, Lin G, Kane GC, et al. Unsupervised Machine Learning for Assessment of Left Ventricular Diastolic Function and Risk Stratification. J Am Soc Echocardiogr. 2022;35(12):1214-1225.e8. doi: 10.1016/j.echo.2022.06.013.

4. Pardi MM, Pomerantzeff PMA, Sampaio RO, Abduch MC, Brandão CMA, Mathias W Jr, et al. Relation of Mitral Valve Morphology to Surgical Repair Results in Patients with Mitral Valve Prolapse: A Three-Dimensional Transesophageal Echocardiography Study. Echocardiography. 2018;35(9):1342-50. doi: 10.1111/echo.14048.

5. Thachil R, Hanson D. Artificial Intelligence in Echocardiography: A Disruptive Technology for Democratizing and Standardizing Health. J Am Soc Echocardiogr. 2022;35(8):A14-A16. doi: 10.1016/j.echo.2022.06.001.

6. Seetharam K, Raina S, Sengupta PP. The Role of Artificial Intelligence in Echocardiography. Curr Cardiol Rep. 2020;22(9):99. doi: 10.1007/s11886-020-01329-7.

7. Pandian NG, Kim JK, Arias-Godinez JA, Marx GR, Michelena HI, Mohan JC, et al. Recommendations for the Use of Echocardiography in the Evaluation of Rheumatic Heart Disease: A Report from the American Society of Echocardiography. J Am Soc Echocardiogr. 2023;36(1):3-28. doi: 10.1016/j.echo.2022.10.009.

8. Silbiger JJ. Advances in Rheumatic Mitral Stenosis: Echocardiographic, Pathophysiologic, and Hemodynamic Considerations. J Am Soc Echocardiogr. 2021;34(7):709-722.e1. doi: 10.1016/j.echo.2021.02.015.

9. Vieira MLC, Branco CEB, Gazola ASL, Vieira PPAC, Benvenuti LA, Demarchi LMMF, et al. 3D Echocardiography for Rheumatic Heart Disease Analysis: Ready for Prime Time. Front Cardiovasc Med. 2021;8:676938. doi: 10.3389/fcvm.2021.676938.

10. Barros GF Filho, Solha I, Medeiros EF, Felix AS, Almeida ALC, Lima JC Jr, et al. Medição Automática de Valva Mitral a Partir de Ecocardiograma Utilizando Processamento Digital de Imagens. Arq Bras Cardiol: Imagem Cardiovasc. 2023;36(1):e371. doi: 10.36660/abcimg.2023371.