

# AI: Opportunities, Capabilities and Limits

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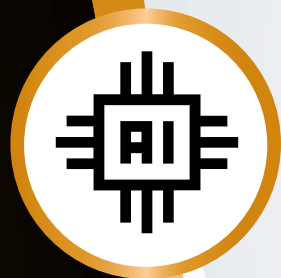
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# AI: Opportunities Capabilities & Limits



# Artificial Intelligence and Echocardiography: Are We Ready for Automation?

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Artificial intelligence has many potential applications in the field of cardiac imaging and echocardiography is not an exception. There are clear examples in different aspects like cardiac chamber quantification, assistance on the interpretation of stress echocardiography or the evaluation of valvular heart disease. We need to be prepared for automation in echocardiography as well as in other fields of cardiology.



## Key Points

- The use of computers to assist with radiologic image interpretation tasks is here to stay.
- The inclusion of artificial intelligence tools in cardiac imaging into daily decision-making will improve care delivery.
- Automation in echocardiography is not really a new concept and has evolved forward.
- Assessment and quantification of left ventricular size and function is a pivotal aspect of echocardiography.
- There are numerous limitations to the use of automated tracing; however, further updates to this technology are ongoing to enhance reproducibility and the user experience.

## Decision Making in Cardiac Imaging

It is probable that the inclusion of artificial intelligence (AI) tools in cardiac imaging into daily decision-making will improve care delivery. But it is also necessary that cardiologists must retain the last step in the control of the system, keep an eye on the decisions and have the authority to change algorithms in cases that AI gets wrong.

In this evolving field, AI applications in cardiology show, for example, that simple tools like electrocardiography (ECG) could bring a lot of potential information converting the ECG into a powerful instrument for prediction (Vidal-Perez 2020).

In the radiology field, the potential influence of AI on the future progress of this medical specialty is obvious. The use of computers to assist with radiologic image interpretation tasks is here to stay, for example, in cardiothoracic imaging, the most widely used subset in medical imaging is machine

learning (ML). A lot of scientific research has focused on the use of ML for pattern recognition to detect and potentially diagnose several pathologies (Moore 2020).

AI and ML models are quickly being applied to the analysis of cardiac computed tomography (CT) as it is an independent tool of a manual approach as echocardiography is. Within echocardiography, the quality of imaging obtained is critical, however for cardiac magnetic resonance or cardiac CT, the quality of the imaging obtained is not a real problem as it is not obtained manually. This combination of ML and cardiac CT (Hyett Bray 2022) is also bringing a lot of advancements such as:

- Non-invasive CT-fractional flow reserve (CT-FFR) can accurately be estimated using ML algorithms and has the potential to reduce the requirement for invasive angiography.



- Coronary artery calcification and non-calcified coronary lesions can now be automatically and accurately calculated.
- Epicardial adipose tissue can also be automatically, accurately, and rapidly quantified.
- Effective ML algorithms have been developed to streamline and optimise the safety of aortic annular measurements to facilitate pre-transcatheter aortic valve replacement valve selection.
- In the field of electrophysiology, the left atrium (LA) can be segmented and resultant LA volumes have contributed to accurate predictions of post-ablation recurrence of atrial fibrillation.

created by multiple vendors has been found to be reproducible, feasible, and accurate for 2D and 3D echocardiographic measurements (Gandhi 2018).

The next step forward is the automated echocardiographic detection of severe coronary artery disease using AI. The point of this innovation is to validate an AI system to automate stress echocardiography analysis and support clinician interpretation. This has been demonstrated with automated image processing pipeline that was developed to extract novel geometric and kinematic features from stress echocardiograms collected as part of a large, UK-based prospective, multicentre, multivendor study. An ensemble ML classifier was trained, employing the extracted features, to identify

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Nevertheless, AI algorithm development is now directed toward workflow management. AI can impact patient care at multiple stages of their imaging experience and assist in efficient and effective scheduling, imaging performance, worklist prioritisation, image interpretation, and quality assurance (Moore 2020).

### Automation in Echocardiography

Automation in echocardiography is not really a new concept and has evolved forward by the works of pioneers such as Chu and colleagues (Chu 1978). In these old studies they used a Fourier analysis technique to process information from the M-mode tracing of the anterior mitral leaflet to detect normal and abnormal cardiac states such as mitral valve prolapse (MVP), rheumatic mitral stenosis, and hypertrophic cardiomyopathy. Using a classifier system, the algorithm was able to identify MVP with accuracy providing optimism for automation in echocardiography (Chu 1979).

Assessment and quantification of left ventricular size and function is a pivotal aspect of echocardiography. Significant variability exists in technique and methods for tracing biplane disc summation to quantify left ventricular volumes and ejection fraction (Gandhi 2018). Prior to conventional ML and deep learning (DL), deformable models showed great promise for border detection, segmentation, shape representation, and motion tracking (McInerney 1996). Automation for measurements using current AI technology has been shown to increase the reproducibility of measurements, bridge the gap between expert and novice readers, and increase efficiency and workflow in echocardiography laboratories. Automated software

patients with severe coronary artery disease on invasive coronary angiography. An acceptable classification accuracy for identification of patients with severe coronary artery disease in the training data set was achieved on cross-fold validation based on 31 unique geometric and kinematic features, with a specificity of 92.7% and a sensitivity of 84.4%. This accuracy was maintained in the independent validation data set from the U.S. This approach of providing automated classifications to clinicians when reading stress echocardiograms could improve accuracy, inter-reader agreement, and reader confidence in the near future (Upton 2022).

The last step in echocardiography, recently published, is the automated analysis of doppler echocardiographic videos as a screening tool for valvular heart diseases (VHDs). The authors of this study (Yang 2022) developed a 3-stage DL framework for automatic screening of echocardiographic videos for mitral stenosis (MS), mitral regurgitation (MR), aortic stenosis (AS), and aortic regurgitation (AR) that classifies echocardiographic views, detects the presence of VHDs, and, when present, quantifies key metrics related to VHD severities. The algorithm was trained (n= 1335), validated (n=311), and tested (n = 434) using retrospectively selected studies from five hospitals. A prospectively collected set of 1374 consecutive echocardiograms served as a real-world test data set. Disease classification accuracy was high, with areas under the curve of 0.99 (95% CI: 0.97-0.99) for MS; 0.88 (95% CI: 0.86-0.90) for MR; 0.97 (95% CI: 0.95-0.99) for AS; and 0.90 (95% CI: 0.88-0.92) for AR in the prospective test data set (Yang 2022).



### Are We Ready for Automation?

There are numerous limitations to the use of automated tracing; however, further updates to this technology are ongoing to enhance reproducibility and the user experience. Most studies assessed patients in sinus rhythm with limited knowledge of the use of automation among patients with significant conduction disease, arrhythmia, and paced rhythm.

provide better patient care? Do we not believe the validity of these results? Or are we just afraid that our jobs are at stake if AI starts to take over some of the tasks that currently we do? In the end, history has shown that it doesn't really matter what we think. We can disagree with or even revolt against these technological advancements, but in the end, they will come— simply because in the long term, it is better for everyone

## AI in stress echocardiography should not be regarded a threat but rather a remarkable opportunity to further enhance the value of an already extremely useful test

Poor and fair-quality images were found to increase erroneous border tracings by the computer, and in several patients, the automated software did not work. This will be a limitation moving forward in the development of this software. Contour adjustments seem to increase accuracy of automated analysis with greater correlation to cardiac MRI; however, this increases analysis time and reduces workflow efficiency. Lastly, automation correlated well with cardiac MRI volumes as traditional 2D measurements have been suggested to underestimate chamber volumes (Gandhi 2018).

Will AI replace echocardiographers? Not anytime soon. AI results must be interpreted in the context of other available echocardiographic and stress testing information. However, AI stands to increase the efficiency and reproducibility of echocardiography; cardiologists must strive to understand AI and be prepared to document its effectiveness. AI in stress echocardiography should not be regarded a threat but rather a remarkable opportunity to further enhance the value of an already extremely useful test (Pellikka 2022).

The question is, if we have so many promising results, why are we not implementing them in clinical practice? Don't we have a moral obligation to use everything in our hands to

(Kolossvár 2022).

Another concern is what to do when man and machine disagree. The importance of outstanding validation of the algorithms must, therefore, be underscored. Clinical judgment by the physician is essential, with a dose of humility as well, to ensure that AI would be used to support and not replace clinical decision-making. Certainly, explainability (the ability to explain how the algorithm came up with its output) can be limited in unsupervised ML, such as with the specialised techniques involved in DL. However, the future remains bright for AI applications in healthcare, as the potential to enhance our practice in the field of medicine is impressive.

### Conclusion

We need to be prepared for automation in echocardiography as we will need it in other fields of cardiology. The future will be bright because the best outcome will probably be found when combining the wisdom and experience of the physicians with AI in a human-AI partnership for success. Therefore, don't be afraid of the rise in automation.

### Conflict of Interest

None. ■

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