Unleashing the Potential of Machine-Based Learning for the Diagnosis of Cardiac Diseases

Sherif F. Nagueh, MD

Imaging plays a critical role in the diagnosis and management of patients with cardiovascular disease. Given the need for cost-effective diagnostic and treatment algorithms and the diversity of available imaging modalities, it is important to identify and use the most cost-effective diagnostic strategies. This is particularly true for patients undergoing evaluation for possible pericardial constriction where an equivocal diagnosis after the initial imaging modality, echocardiography, can lead to additional testing, including cardiac catheterization. Thus, the warm welcome for the study by Sengupta et al in this issue of Circulation: Cardiovascular Imaging. The authors used clinical and echocardiographic data of 50 patients with constrictive pericarditis and 44 patients with restrictive cardiomyopathy to develop a machine learning–based algorithm: an associative memory classifier (AMC). Findings in 47 controls were also gathered, and then AMC was applied to identify patients with constriction from those with restriction.

See Article by Sengupta et al

Results of the Present Study

Studying the performance of standard criteria was an integral part of the analysis of this study. Notably, standard criteria were applicable to all initial patients. However, 9 patients were excluded because of tracking problems and thus were not included in the analysis using machine learning algorithms. This highlights the lower feasibility of an approach based on strain and strain rate measurements.

The AMC leaning algorithm was based on several variables, including displacement, velocity, strain, and strain rate from the apical 4-chamber view and the parasternal short-axis view at the midventricular level. The authors did not disclose why the speckle tracking (STE)-derived data were obtained from these 2 views only. During the training phase, variables of each patient were analyzed to obtain several predictors. Predictors were then combined to help identify the 2 diseases. The analysis allowed for a windowing function to deal with new variables that were not observed in the training data set. The authors also compared analysis by AMC to other general machine learning algorithms. They observed that AMC performed better than other machine learning approaches and needed fewer training trials.

As expected, there were significant differences in routinely analyzed imaging parameters between patients with pericardial constriction and those with restrictive cardiomyopathy (the majority of which had cardiac amyloidosis). Thus, most patients with pericardial constriction had normal left ventricular wall thickness. In comparison, patients with restriction had higher E/e' ratio, lower e' velocity, and more impaired left ventricular longitudinal strain. Importantly, a wide overlap was present between the 2 groups in left ventricular longitudinal strain based on the mean and SD values in Table 2, and thus, the area under the curve of only 63.7% for the latter variable. The frequency of abnormal septal motion (septal bounce) in patients with constriction was not presented. Likewise, the performance of a recently published simple algorithm for the diagnosis of constriction was not included in the analysis.

Machine-Based Learning

The concept of machine-based learning has been entertained for years, and the authors have successfully applied it to diagnose 2 challenging diseases. Although interesting, the study serves as an initial step toward a well-developed approach because it has several limitations, some of which were already acknowledged by the authors. First, the training data set were obtained from a select group of patients imaged at a single site. The accuracy of the algorithm depends in part on the volume and quality of data used for training, and it is possible to use a different set of combinations in the final model by including more patients with a wider disease spectrum and with different etiologies from those included in this study. Thus, having a large database is essential for a more robust derivation of an algorithm. Second, prospective validation is essential before its endorsement and adoption. Further, the majority of variables included and derived from STE were segmental volumes, displacement, velocity, and systolic strain/strain rate parameters. For most clinical laboratories, these signals are less reproducible compared with 2D and routine Doppler measurements.

Both constriction and restriction affect left ventricular filling, yet the variables selected from STE-based measurements were systolic. The presence of abnormal myocardial function in patients with restriction can help explain the contribution of systolic parameters to the diagnosis. Nevertheless, the absence of diastolic variables from the panel of STE-derived predictors is interesting. One reason why STE-derived diastolic variables were not included could be that once mitral annulus e' velocity...
is entered in the model, no additional incremental information is provided by diastolic strain rate variables. Alternatively, the lower reproducibility of diastolic strain rate variables could account for their absence from the final model.

What the Future Holds
Sengupta et al have reopened the door to machine-based learning using STE derived measurements in patients with pericardial constriction and restrictive cardiomyopathy. They have shown the feasibility and accuracy of such an approach. One can think of several steps to follow. These include showing the incremental value of machine-based learning to society-recommended standard algorithms for experienced and novice readers, the impact of study quality on the accuracy of AMC, and prospective validation of machine learning–based algorithms. In the current study, standard echocardiographic measurements (e′, E/e′, septal, and posterior wall thickness) performed well with an area under the curve of 94.2%. When these same variables were combined with 15 STE-derived variables, the area under the curve had a minimal increase to 96.2%. Thus, it is difficult to make a strong case for AMC based on these results. On the contrary, it is likely that AMC can add much more to the accuracy of echocardiographic diagnoses in other situations as in stress echocardiography in patients with single vessel disease involving the right or circumflex coronary arteries.

Disclosures
None.

References

Key Words: Editorials ▪ cardiomyopathy ▪ cardiovascular disease ▪ constrictive pericarditis ▪ diastolic dysfunction cardiomyopathy ▪ pericarditis
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_Circ Cardiovasc Imaging_. 2016;9:
doi: 10.1161/CIRCIMAGING.116.005059
_Circulation: Cardiovascular Imaging_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 1941-9651. Online ISSN: 1942-0080

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