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EDITORIAL COMMENT

Post-Myocardial Infarction Risk Prediction

Does Ventricular Shape Matter?*

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Despite great advances in the care of patients with acute myocardial infarction (MI), mainly timely invasive management and long-term pharmacotherapy, patients are still at high risk for long-term adverse events. Cardiovascular imaging has experienced much development, but prediction of long-term events is still today based on a crude parameter: left ventricular ejection fraction (LVEF). There is a clinical need to identify better predictors that can improve risk stratification in post-MI patients. From all imaging modalities, cardiac magnetic resonance (CMR) is the preferred because it can evaluate cardiac anatomy, function, perfusion, and even tissue composition.[1] Several CMR parameters have been shown to predict long-term events in the post-MI population (**Table 1**), but to date none of them has replaced LVEF for guiding the treatment of patients.

Artificial intelligence (AI) is revolutionizing the field of cardiovascular imaging by providing deep learning tools for image acquisition, reconstruction, and analysis. Machine learning approaches offer the possibility of identifying unexplored predictive models that could overcome the risk-stratifying limitations of traditional image analysis.

Left ventricular volumes and LVEF are global ventricular performance parameters, neglecting spatial inhomogeneities that can alter ventricular shape and contraction, possibly altering the prognosis of post-MI patients. To test this hypothesis, in this issue of *JACC: Cardiovascular Imaging*, Corral et al[2] used deep learning solutions to segment the LV in a 3-dimensional (3D) mode with an automated pipeline analysis in a regional and global manner. The objective was to find specific 3D features in the early post-MI period with long-term prognostic capacity. CMR data sets and paired clinical follow-up details were collected from 1,201 patients recruited in the AIDA-STEMI (Abciximab i.v. Versus i.c. in ST-elevation Myocardial Infarction) and TATORT-NSTEMI (Thrombus Aspiration in ThrOmbus Containing culprit Lesions in Non-ST-Elevation Myocardial Infarction) trials. A strength of the present study is that, in contrast to most of the previous prognostic analyses, it includes a combination of STEMI and non-STEMI patients. Adverse events during follow-up were defined as the first occurrence of any of the following: all-cause death, reinfarction, and new congestive heart failure. The main result of this study is that the newly built AI-based parameters (LV end-systolic shape and 3D contraction, as compared with LV end-systolic volume and LVEF) modestly improved risk prediction in survivors of acute AMI. Specific segmental contraction patterns (ie, global, anterior, and basal impairments) were found to have the most relevant added prognostic value.

The authors are to be commended for performing a novel and elegant study. Their conclusion that LV shape and contraction patterns have a prognostic value is solid, and certainly they met their goal. From a clinical perspective, the implications are, however, less straightforward. The improvement in risk prediction was very modest compared with classic parameters. In addition, the outcomes chosen as the clinical endpoints are very disparate. All-cause mortality and reinfarction are not necessarily related to any LV 3D anatomy or function, and they probably

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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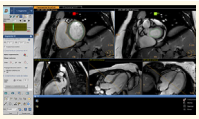
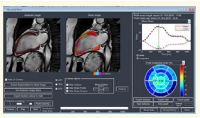
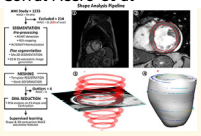
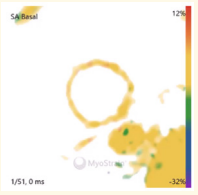
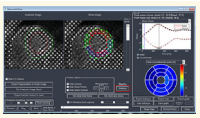
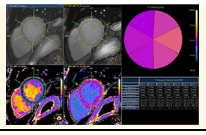
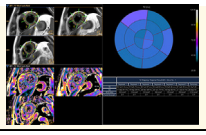
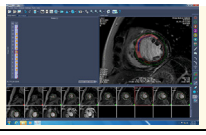
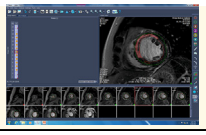
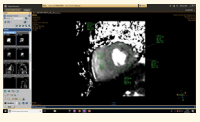
TABLE 1 CMR Techniques With Prognostic Capacity in the Postinfarction Population

CMR Acquisition Sequences	Morphology and Function				
	2D (SSFP or Fast GE) and 3D Cine			DENSE/SENC/ Fast SENC	Tagging
Process	Global volumetric changes	Regional strain	Shape characterization	Regional strain	Regional strain
Parameters and tools	LV ED/ES volumes, LVEF	Feature tracking	Deep learning	Myocardial deformation	Myocardial tagging
Prognostic capacity	Fully established	Barely established	Partially established	Barely established	Barely established
First Author	Burns et al[6]	Podlesnikar et al[7]	Corral Acero et al[2]	Mangion et al[8]	Shetye et al[9]
Analysis example					

CMR Acquisition Sequences	Myocardial Tissular Characterization				
	T1 Mapping	T2 Weighted, T2 Mapping, T2*	T1 Inversion Recovery		Perfusion and Cine Stress Imaging
Process	Diffuse fibrosis	Edema, hemorrhage	Microvascular obstruction	Infarcted tissue	Ischemia
Parameters and tools	Native T1 times; post-contrast T1 times, extracellular volume	Native T2 times; T2* times	Early gadolinium enhancement, perfusion	Late gadolinium enhancement	First pass perfusion and contractility after vasodilator administration
Prognostic capacity	Barely established	Partially established	Partially established	Fully established	Barely established
First Author	Kidambi et al[10]	Hamirani et al[11]	de Waha et al[12]	Stone et al[13]	Heitner et al[14]
Analysis example					

2D = 2-dimensional; 3D = 3-dimensional; CMR = cardiac magnetic resonance; DENSE = displacement encoding with stimulated echoes; ED = end-diastolic; ES = end-systolic; GE = gradient echo; LV = left ventricle; LVEF = left ventricular ejection fraction; SENC = strain-encoded; SSFP = steady-state free precession.

reflect different pathophysiological intermediates. In fact, authors recognize in the limitations section that the main objective of the study was not to evaluate the prediction of major adverse cardiac events but to confirm the hypothesis that LV shape analysis in the acute phase can have a long-term prognostic impact. Importantly, the authors made publicly available a reference atlas with information about average LV shape and contraction from this post-MI population, and this is certainly a major feature of their study.

The authors used available CMR data from 2 randomized clinical trials. When the global CMR findings are studied, it can be argued that these populations were in general low-risk ones because the median LVEF was 50%, the infarct size was 13% of the LV, and microvascular obstruction was almost absent. The inclusion of patients with poorer LV performance could have magnified the predictive capacity of their newly proposed parameters. Another limitation is that there is no external validation cohort.

There are some caveats from the conceptual perspective. First, CMR was performed very early after an acute MI (median time from index event to CMR was 3 days), and any potential change in LV shape and/or 3D contraction in the weeks after MI were not picked up. The pathological process after an MI is known to be extremely dynamic.[3] Second, the proposed CMR functional analysis does not focus on the whole cardiac cycle but only on end-systolic and end-diastolic information. A static view of a dynamic parameter (LV shape and 3D contraction) does not seem to be an ideal marker of future outcomes. Finally, myocardial tissue composition was not included in the proposed algorithm, concentrating the whole analysis on LV shape and contraction modes.

In the present study, global and regional contractility information were obtained from standard 2D cine images. Recently, different ultra-fast 3D cine acquisitions have been developed that are able to

obtain actual 3D cine functional information about the whole heart in a single breath-hold.[4] Beyond this, technological advances have made it possible to measure and quantify myocardial wall motion by CMR strain imaging. Myocardial deformation can be routinely assessed in a regional manner using feature tracking algorithms, tagging, phase velocity mapping, displacement encoding with stimulated echoes, or strain-encoded sequences.[5] The use of 3D acquisitions and algorithms able to characterize the tissue can theoretically improve the ability to stratify prognosis, albeit this is speculative.

In summary, the present study opens a new window for considering LV shape and contractile pattern as potential predictors of poor long-term prognosis. While we await a prospective independent study validating these results, the "old acquaintance" parameter LVEF will remain as the only parameter guiding treatment strategy in post-MI patients.

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