

# Automated CMR index of left ventricular diastolic function post-acute myocardial infarction provides independent and incremental prediction of long-term prognosis when added to conventional indices

Mayooran Shanmuganathan<sup>1\*</sup>, Ricardo A. Gonzales<sup>1\*</sup>, Matthew K. Burrage<sup>1</sup>, Per M. Arvidsson<sup>1,2</sup>, Abhirup Banerjee<sup>3</sup>, Irem Çakir<sup>1</sup>, Felicia Seemann<sup>2</sup>, OxAMI Study Investigators, Einar Heiberg<sup>2</sup>, Dana C. Peters<sup>4</sup>, Qiang Zhang<sup>1</sup>, Keith M. Channon<sup>3</sup>, Stefan K. Piechnik<sup>1</sup>, and Vanessa M. Ferreira<sup>1</sup>

<sup>1</sup>Oxford Centre for Clinical Magnetic Resonance Research (OxCMR), Division of Cardiovascular Medicine, Radcliffe Department of Medicine, John Radcliffe Hospital, University of Oxford, Oxford, United Kingdom

<sup>2</sup>Department of Clinical Sciences, Lund University, Skåne University Hospital, Lund, Sweden

<sup>3</sup>Division of Cardiovascular Medicine, Radcliffe Department of Medicine, John Radcliffe Hospital, University of Oxford, Oxford, United Kingdom

<sup>4</sup>Department of Radiology and Biomedical Imaging, Yale School of Medicine, Yale University, New Haven, CT, United States

\*These authors have contributed equally to this work and share first authorship.

## Background

CMR-assessment of left ventricular (LV) systolic function and infarct size (IS) are amongst the most powerful predictors of long-term outcomes after acute myocardial infarction (AMI). Diastolic dysfunction has also been documented in AMI, but: 1) it has not been systematically quantified using CMR and 2) its long-term prognostic implication post-MI is unclear. Artificial Intelligence (AI) in CMR enables automated and consistent measurement of early diastolic velocity of the LV longitudinal motion ( $e'$ ) - a marker of LV diastolic function<sup>1</sup>. This study aimed to assess the performance of CMR-derived  $e'$  in predicting long-term clinical outcomes post-AMI.

## Methods

We prospectively recruited 219 patients who underwent primary percutaneous intervention for ST-segment-Elevation MI (STEMI) and CMR at a median 2 [1-2] days which included long and short-axis cine and late gadolinium enhancement. The LV early diastolic velocity ( $e'$  in cm/s) was obtained using automated annotation of the mitral valve insertion points on the septal and lateral walls in the 4-chamber cine, and anterior and inferior walls in the 2-chamber cine<sup>1</sup> (Figure 1A). A *global LV  $e'$*  was computed as an average of the four measurements. Conventional CMR metrics (LV ejection fraction (LVEF), IS and presence of microvascular obstruction (MVO)) were assessed as previously described<sup>2</sup>. All patients were followed up for clinical outcomes. Primary end-point was a composite of cardiac death, survived cardiac arrest or new-onset heart failure.

## Results

197/219 patients (mean age: 61±11; 86% male) had good quality cines allowing the derivation of *global LV  $e'$*  (mean 4.92±1.76 cm/s). Average LVEF was 47±9% and IS was 24±14% while MVO was present in 51%. 21/197 (11%) patients experienced a primary end-point at a median of 3.9 [2.5-6] years follow-up. On univariate Cox-regression analysis, LVEF < 40% (hazard ratio (2.8(1.8-7.7);  $p = 0.019$ ), IS > 17% (3.5(1.0-12.1);  $p = 0.004$ ), MVO presence (3.7(1.3-11.2);  $p = 0.018$ ) and *global LV  $e'$*  (0.53 (0.34-0.74);  $p \leq 0.001$ ) were predictors of outcomes (Table 1A). On multivariate analysis, *global LV  $e'$*  was the only independent predictor of outcomes. This remained the case even after adjusting for clinical confounders (Table 1B). A *global LV  $e' \leq 4$ cm/s* was associated with a 6.8-fold (2.5-18.7;  $p < 0.001$ ) increase in risk of long-term primary end-point (Figure 1B). When added to models containing the conventional CMR indices, *global LV  $e'$*  improved their risk prediction [C-statistics (0.70±0.06 vs 0.82±0.05,  $p < 0.001$ ), Brier score (0.066 vs 0.063) and the Integrated discrimination Improvement Index (6.3% (0.4-19.3);  $p = 0.027$ )].

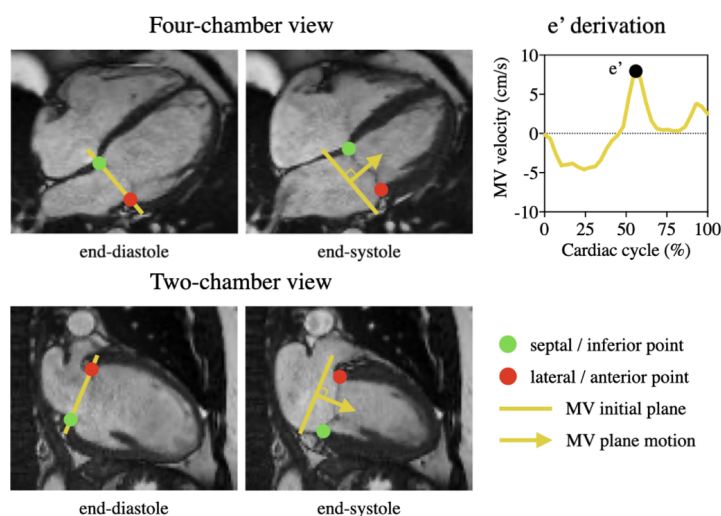
## Conclusion

LV diastolic dysfunction (early diastolic velocity (*global LV e'*) measured automatically by an AI method on CMR cine) at 2 days after reperfused acute-STEMI provides independent and incremental prediction of long-term prognosis, beyond LVEF, infarct size and MVO.

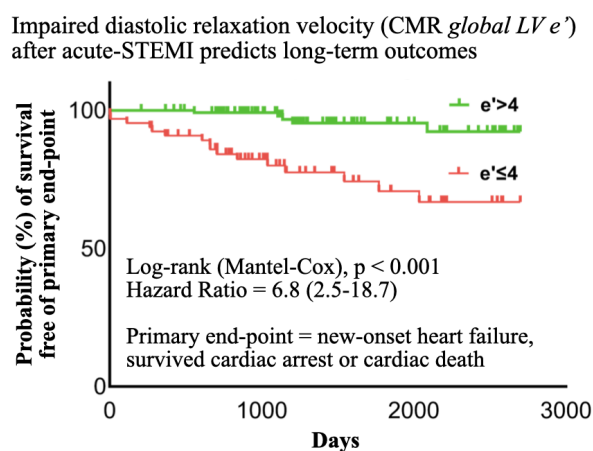
## References

1. Gonzales, R. A. *et al.* MVnet: automated time-resolved tracking of the mitral valve plane in CMR long-axis cine images with residual neural networks: a multi-center, multi-vendor study. *J. Cardiovasc. Magn. Reson.* **23**, 137, DOI: <https://doi.org/10.1186/s12968-021-00824-2> (2021).
2. Shanmuganathan, M. *et al.* Acute response in the noninfarcted myocardium predicts long-term major adverse cardiac events after STEMI. *JACC: Cardiovasc. Imaging* **16**, 46–59, DOI: <https://doi.org/10.1016/j.jcmg.2022.09.015> (2023).

### (A) Automated CMR *global LV e'* derivation



### (B) Kaplan-Meier survival analysis



**Figure 1.** *Global LV e' < 4* (derived as an average of the 4 *e'* values obtained from 4-chamber and 2-chamber cine images) is associated with a 6.8-fold increase in adverse long-term outcomes after STEMI.

**Table 1.** Univariate and Multivariate Cox Regression Analyses of Conventional CMR and *Global LV e'* Indices.

<b>(A) Univariate Cox Regression Model</b>		
<b>Variable</b>	<b>Hazard Ratio (95% CI)</b>	<b>p value</b>
Acute LVEF < 40%	4.274 (1.768-10.329)	0.001
Infarct size > 17%	3.441 (1.001-11.827)	0.050
MVO presence	3.784 (1.256-11.405)	0.018
History of MI	5.366 (1.757-16.383)	0.003
Ischaemic time (minutes)	1.002 (1.001-1.003)	0.003
<b><i>Global LV e'</i> (cm/s)</b>	<b>0.527 (0.375-0.742)</b>	<b>&lt;0.001</b>
<b><i>Global LV e' ≤ 4 cm/s</i></b>	<b>6.841 (2.503-18.696)</b>	<b>&lt;0.001</b>
<b>(B) Multivariate Cox Regression Model</b>		
<b>Variable</b>	<b>Hazard Ratio (95% CI)</b>	<b>p value</b>
Acute LVEF < 40%	2.174 (0.654-7.229)	0.205
Infarct size > 17%	1.275 (0.243-6.691)	0.774
MVO presence	2.336 (0.534-10.230)	0.260
Age (years)	1.017 (0.962-1.076)	0.548
History of MI	7.110 (1.348-37.506)	0.021
Ischaemic time (minutes)	3.643 (1.169 -11.357)	0.014
<b><i>Global LV e'</i> (cm/s)</b>	<b>0.628 (0.408-0.966)</b>	<b>0.034</b>