

# Letters

## RESEARCH LETTER

### Value of Cardiovascular Magnetic Resonance Imaging–Derived Baseline Left Ventricular Ejection Fraction and Volumes for Precise Risk Stratification of Patients With Ischemic Cardiomyopathy: Insights From the Surgical Treatment for Ischemic Heart Failure (STICH) Trial

Ischemic cardiomyopathy accounts for approximately 50% of patients with heart failure and one-third of the patients undergoing coronary artery bypass surgery.<sup>1</sup> Left ventricular (LV) ejection fraction (EF) and end-systolic volume index (ESVI) are predictors of mortality in these patients. Cardiovascular magnetic resonance (CMR) imaging can provide precise estimates of LV volumes and function. In the Surgical Treatment for Ischemic Heart Failure (STICH) Trial population,<sup>2</sup> we tested the hypothesis that CMR-derived LVEF and volumes would provide improved risk stratification.

**Methods** | The rationale, patient enrollment, and inclusion and exclusion criteria for the surgical arm of the STICH Trial have

been previously described.<sup>2-4</sup> Briefly, this study included patients with LVEF of 35% or less, apical dyssynergy, coronary anatomy suitable for revascularization, age 18 years or older, and the ability of the patient to give informed consent.<sup>1-5</sup> A baseline CMR study was performed, although it was not mandated by the protocol.

The protocol was developed and analyzed by the CMR Core Laboratory. Cardiac-gated CMR studies were performed on commercially available 1.5-T or 3-T platforms from an international group of hospitals. Short-axis cine imaging studies were used to determine LV volumes and EF using the Simpson method. Each of the participating institutions obtained approval from their respective institutional review boards. Written consent was obtained from all patients.

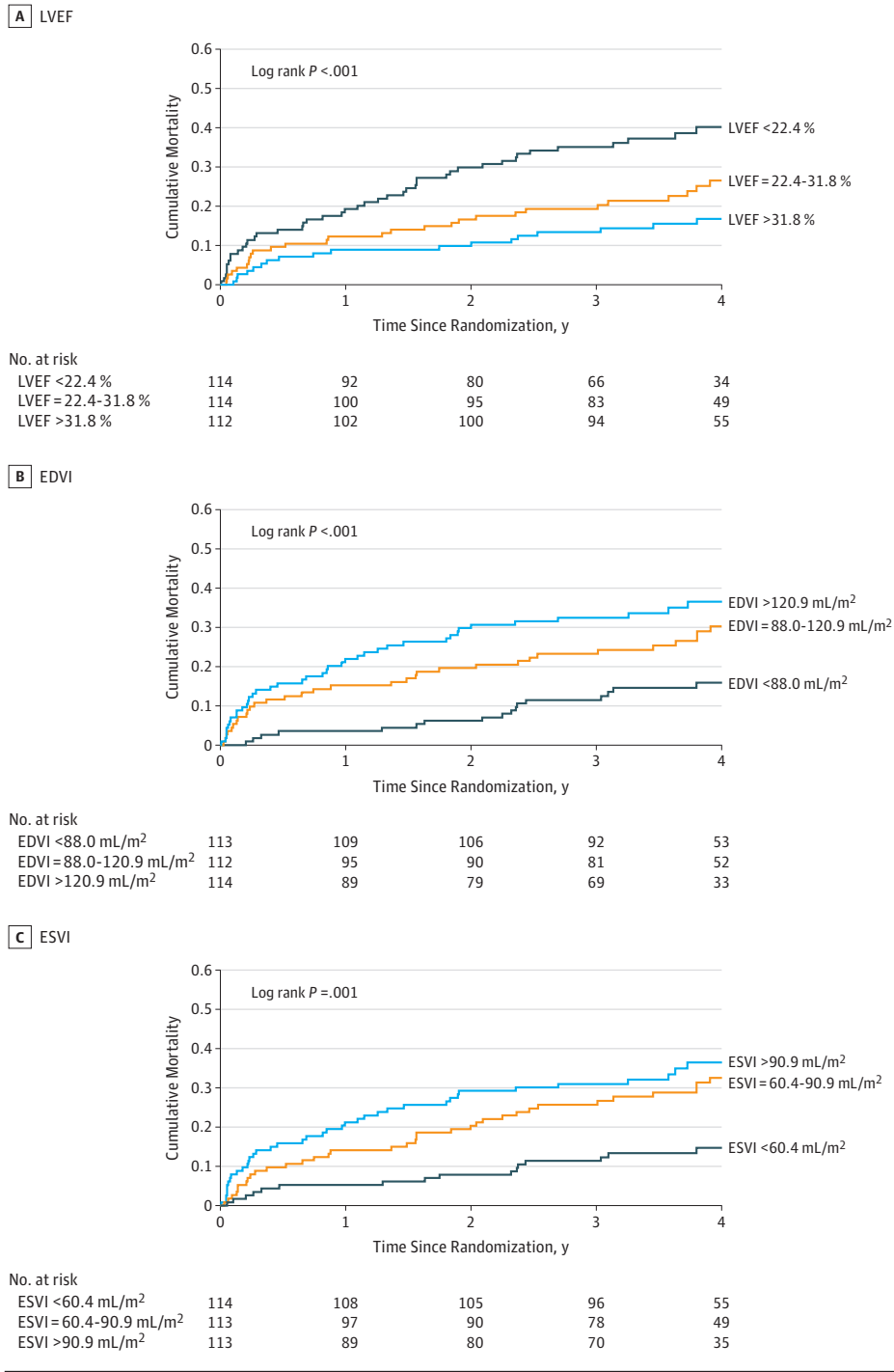
**Results** | Of the 1000 surgical ventricular reconstruction-eligible patients, 340 had baseline CMR studies and 660 did not; both groups were similar except for a slightly higher prevalence of renal insufficiency in those who did not have a CMR study (Table). The mean (SD) age of the CMR group was 60.9 (9.8) years, the mean (SD) LVEF was 28% (11%), the mean (SD)

Table. Baseline Clinical and CMR Measurements

Variable	No. (%)			
	All Patients		CMR Patients	
	With No CMR (n = 660)	With CMR (n = 340)	With CABG Only (n = 177)	With CABG Plus SVR (n = 163)
Age, mean (SD), y	62.0 (9.6)	60.9 (9.8)	61.3 (9.9)	60.4 (9.7)
Women	100 (15.2)	47 (13.8)	24 (13.6)	23 (14.1)
Hypertension	384 (58.6)	198 (58.2)	101 (57.1)	97 (59.5)
Diabetes	230 (34.8)	114 (33.5)	57 (32.2)	57 (35.0)
Stroke	39 (5.9)	17 (5.0)	8 (4.5)	9 (5.5)
Peripheral vascular disease	106 (16.1)	40 (11.8)	26 (14.7)	14 (8.6)
Renal insufficiency	62 (9.4)	23 (6.8)	10 (5.6)	13 (8.0)
Atrial fibrillation	82 (12.4)	35 (10.3)	18 (10.2)	17 (10.4)
Heart rate, mean (SD), bpm	67 (12)	70 (13)	70 (14)	70 (12)
Blood pressure, mean (SD), mm Hg				
Systolic	121 (17)	120 (18)	121 (18)	120 (18)
Diastolic	73 (12)	74 (11)	74 (10)	75 (11)
LV ejection fraction, mean (SD), %	NA	28 (11)	28 (11)	27 (12)
LV, mean (SD), mL/m <sup>2</sup>				
End-diastolic volume index	NA	108 (39)	106 (36)	112 (42)
End-systolic volume index	NA	80 (36)	77 (33)	83 (39)
Aspirin use	488 (74)	278 (82)	143 (81)	135 (84)
Angiotensin-converting enzyme inhibitors	574 (87)	302 (89)	159 (90)	143 (88)
Statin use	502 (76)	270 (79)	140 (79)	130 (80)
β-Blocker use	548 (83)	308 (91)	159 (90)	149 (91)
ICD use				
At baseline	33 (5.0)	1 (0.3)	1 (0.6)	0 (0)
During follow-up	114 (17.3)	72 (21.2)	41 (23.2)	31 (19.0)

Abbreviations: bpm, beats per minute; CABG, coronary artery bypass grafting; CMR, cardiovascular magnetic resonance; ICD, implantable cardioverter defibrillator; LV, left ventricular; NA, not applicable; SVR, surgical ventricular reconstruction.

**Figure. Kaplan-Meier Curves of Survival of Patients as a Function of Measures of Left Ventricular (LV) Ejection Fraction (EF), End-Diastolic Volume Index (EDVI), and End-Systolic Volume Index (ESVI) Separated by Tertiles**



end-diastolic volume index was 108 (39) mL/m<sup>2</sup>, and the mean (SD) ESVI was 80 (36) mL/m<sup>2</sup>.

Based on Kaplan-Meier estimates, at 4 years, there were 102 deaths (28%). The **Figure** shows the survival curves of patients divided into tertiles of LVEF and volume indices. There was a graded increase in mortality in patients with lower EFs. Similarly, mortality was higher in patients with larger LV volume indices.

We created multivariable models of survival outcomes adjusting for the effects of clinical and pharmacological variables and treatment assignment (age; sex; hypertension; diabetes; smoking; stroke; peripheral vascular disease; renal insufficiency; β-blocker, angiotensin-converting enzyme inhibitor, angiotensin receptor blocker, statin, and aspirin use; and assignment to surgical ventricular reconstruction or no surgical ventricular reconstruction groups). Adjusted for these

variables, CMR EF was a strong predictor of survival (Wald  $\chi^2$ , 11.9; hazard ratio, 0.84 per 5%; 95% CI, 0.76-0.93;  $P < .001$ ). Left ventricular end-diastolic volume index (hazard ratio, 1.11 per 10 mL/m<sup>2</sup>; 95% CI, 1.05-1.17;  $P < .001$ ) and LVESVI (hazard ratio, 1.12 per 10 mL/m<sup>2</sup>; 95% CI, 1.05-1.19;  $P < .001$ ) were incrementally predictive of outcomes when added individually to the model including CMR EF.

Mortality over 4 years of follow-up was 19% in those with CMR EFs greater than 30%, 34% in those with EFs of 20% to 30%, and 33% in those with an EF less than 20%. Adding CMR LVESVI to EF improved the discriminating power of CMR analysis. The 4-year mortality rates were 0% in those with an EF greater than 30% and ESVI less than 30 mL/m<sup>2</sup>, as well as 37% in those with an EF less than 20% and ESVI greater than 80 mL/m<sup>2</sup>.

**Discussion** | This study adds many insights into the diagnostic evaluation of patients with ischemic cardiomyopathy. Data quality is high in this prospectively studied population within the STICH clinical trial environment. This study demonstrates that the combination of CMR-determined LVEF with ESVI provides good annual mortality risk.

To our knowledge, the present study provides the largest population of patients with ischemic cardiomyopathy that has used CMR to predict surgical outcomes. In the Digitalis Investigation Group Trial, a diminishing EF was associated with an increase in mortality in a graded fashion. However, it has been suggested in other studies that there may be an inflection point at approximately 25% below which there is no apparent further reduction in mortality.<sup>5,6</sup> Using CMR-determined LVEF in combination with LVESVI allows improvement in risk stratification in patients with severe LV dysfunction.

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