Radiology

# Early T1 Myocardial MRI Mapping: Value in Detecting Myocardial Hyperemia in Acute Myocarditis

*Anna Palmisano, MD • Giulia Benedetti, MD • Riccardo Faletti, MD • Paola M. V. Rancoita, PhD • Marco Gatti, MD • Giovanni Peretto, MD • Simone Sala, MD • Edda Boccia, PhD • Marco Francone, MD, PhD • Nicola Galea, MD, PhD • Cristina Basso, MD, PhD • Alessandro Del Maschio, MD • Francesco De Cobelli, MD • Antonio Esposito, MD*

From the Experimental Imaging Centre, Radiology Unit, IRCCS San Raffaele Scientific Institute, Vita-Salute San Raffaele University, Via Olgettina 60, 20132 Milan, Italy (A.P., G.B., E.B., A.D.M., F.D.C., A.E.); School of Medicine, Vita-Salute San Raffaele University, Milan, Italy (A.P., A.D.M., F.D.C., A.E.); Department of Radiology, Guy's and St Thomas' NHS Foundation Trust, London, England (G.B.); Department of Surgical Sciences, Radiology Unit, University of Turin, Turin, Italy (R.F., M.G.); University Centre for Statistics in the Biomedical Sciences, Vita-Salute San Raffaele University, Milan, Italy (P.M.V.R.); Department of Cardiac Electrophysiology and Arrhythmology, IRCCS San Raffaele Scientific Institute, Milan, Italy (G.P., S.S.); Department of Radiological, Oncological and Pathological Sciences, "La Sapienza" University of Rome, Rome, Italy (M.F., N.G.); and Cardiovascular Pathology Unit, Department of Cardiac, Thoracic, Vascular Sciences and Public Health, University of Padua, Padua, Italy (C.B.). Received July 19, 2019; revision requested September 5; revision received December 5; accepted January 2, 2020. **Address correspondence to** A.E. (e-mail: *esposito.antonio@hsr.it*).

Supported in part by a grant from the Italian Ministry of Health (Giovani Ricercatori–Ricerca Finalizzata, GR-2013-02356832).

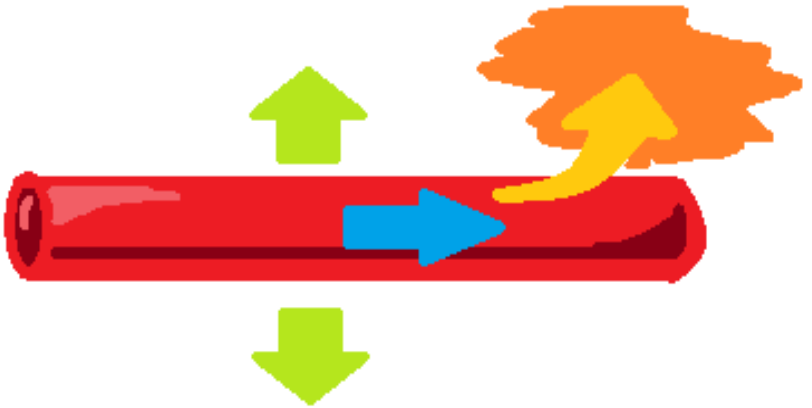
Conflicts of interest are listed at the end of this article.

See also the editorial by De Cecco and Monti in this issue.

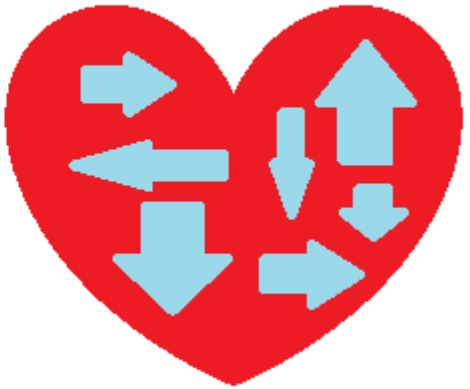
**Radiology 2020; 295:316–325 • https://doi.org/10.1148/radiol.2020191623 • Content codes: CA MR**

S 49-85%
E 43-100%
Ex 63%

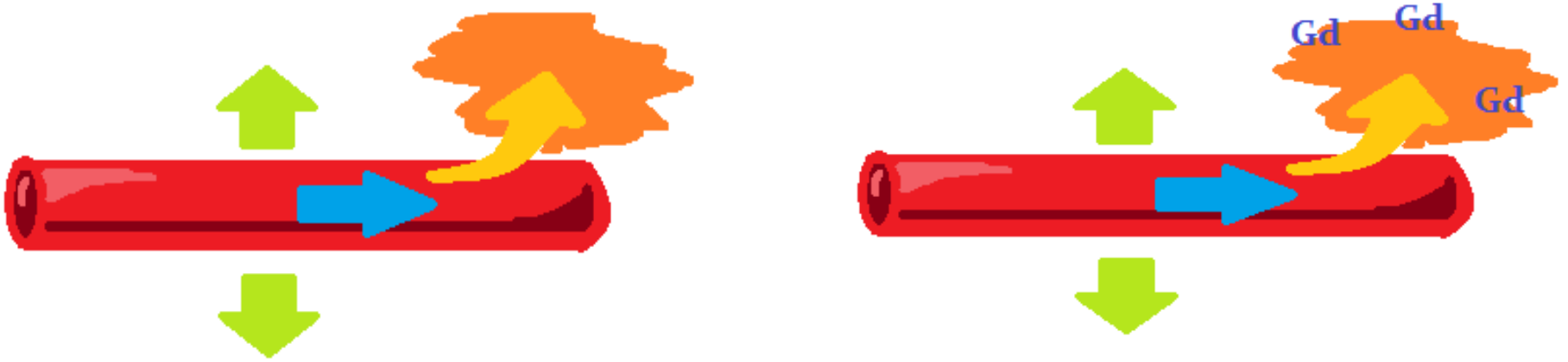
LLC 2009

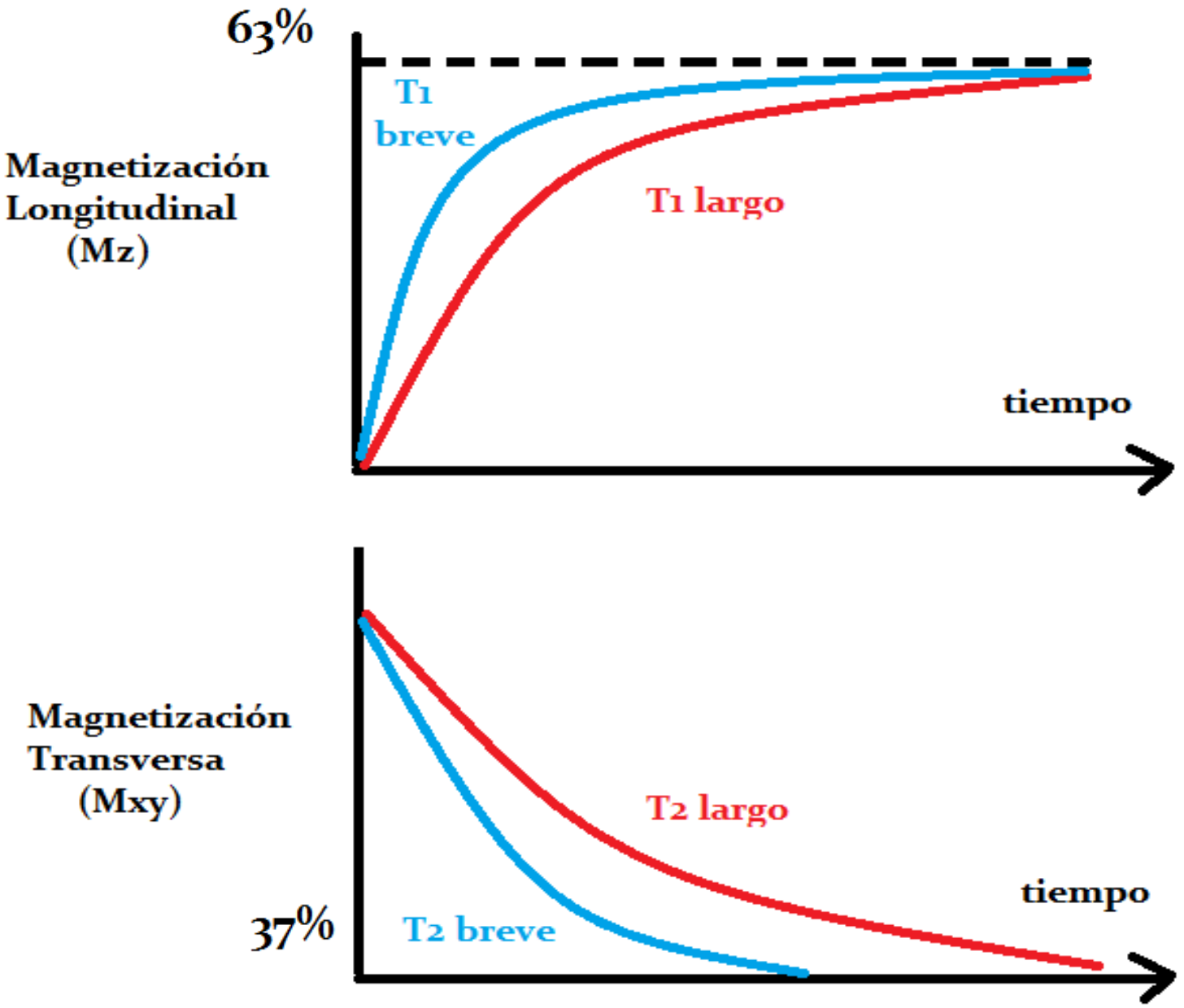


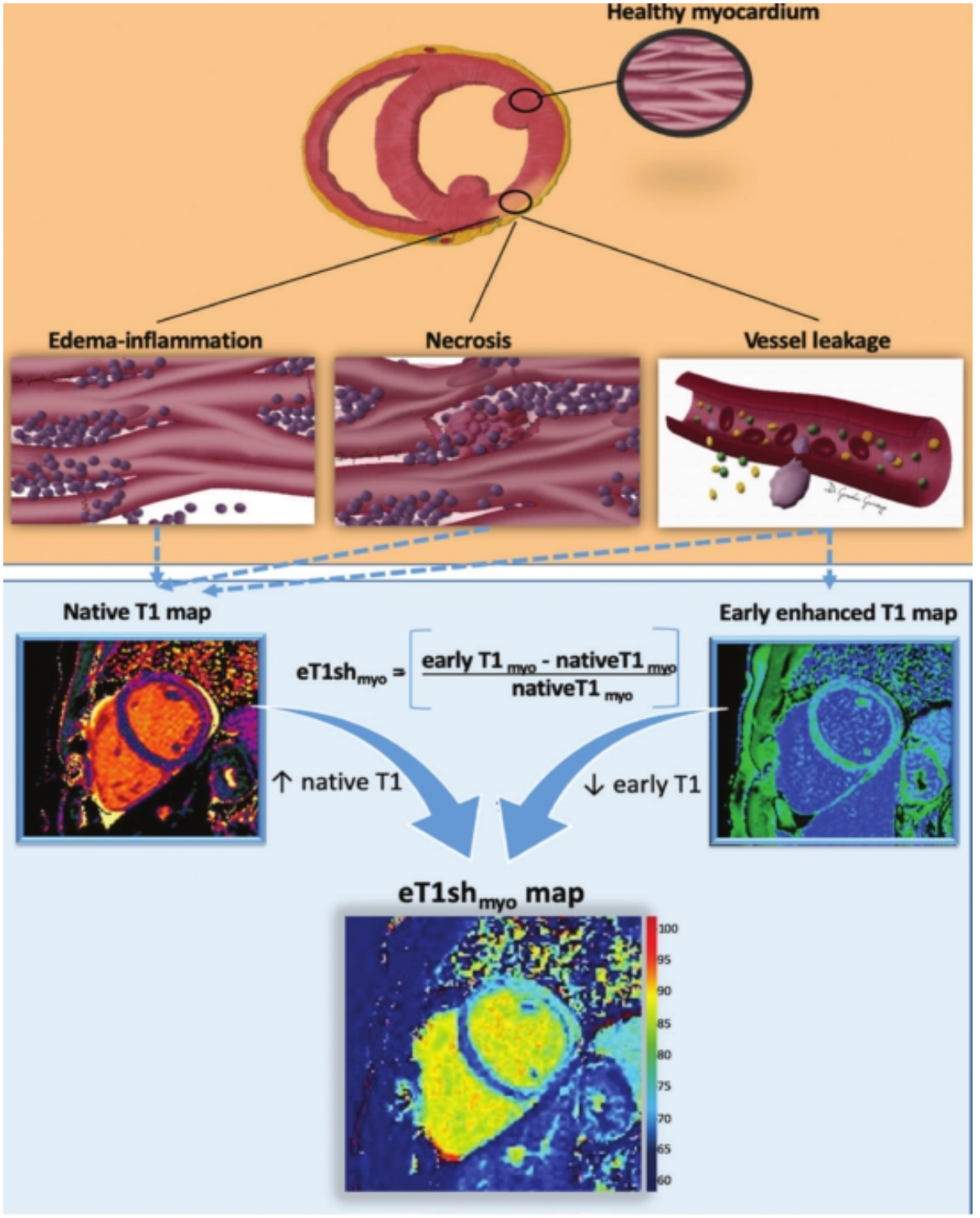
SSFP
(FIESTA)



T1 Gd temprano (2 min) → ? → ↑S




63%
T1
breve
Magnetización
Longitudinal
(Mz)
T1 largo
tiempo
Magnetización
Transversa
(Mxy)
T2 largo
tiempo
37%
T2 breve


Healthy myocardium
Edema-inflammation
Necrosis
Vessel leakage
Native T1 map
Early enhanced T1 map
eT1sh_myo = [ early T1_myo - nativeT1_myo / nativeT1_myo ]
↑ native T1
↓ early T1
eT1sh_myo map
100
95
90
85
80
75
70
65
60

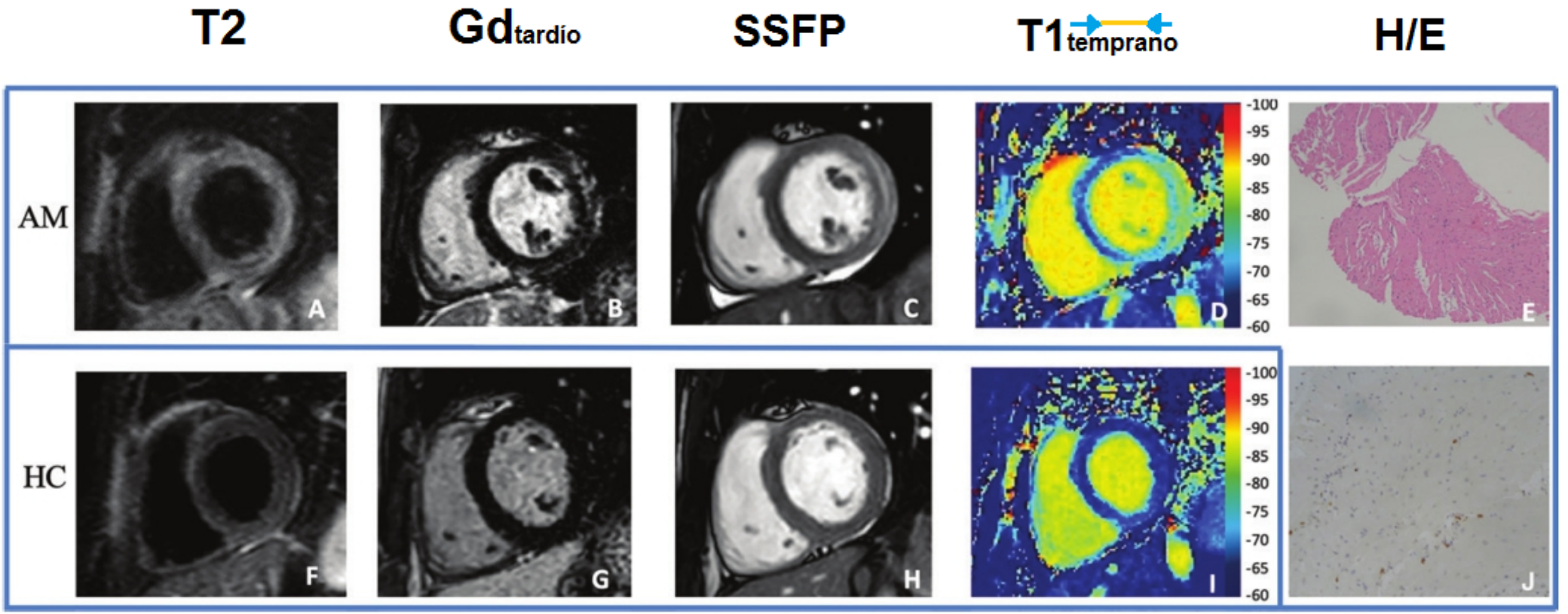



**Figure 5:** Cardiac MRI in a participant with acute myocarditis (AM) and in a healthy control (HC) participant. In a 22-year-old man with AM (top), cardiac MRI shows, *A*, subepicardial edema involving the lateral wall associated with, *B*, small subepicardial anterolateral late gadolinium enhancement and, *C*, hyperintensity on a contrast-enhanced steady-state free precession image. Colorimetric map of early T1 shortening, *D*, in a participant with a mean value of 71%, over the cut-off of 70% found in our study, shows particular increase of early T1 shortening values in the lateral wall with peak of 78% in the subepicardium (in green). Acute myocarditis was confirmed at, *E*, histologic analysis with hematoxylin and eosin stain and at, *J*, immunohistochemical staining. Interstitial edema and cardiac myocytes necrosis was evident in *E* associated with T-lymphocytes infiltrates (CD3+ > 7/mm$^2$) in *J*. Cardiac MRI in a 37-year-old HC participant was negative in, *F*, T2 short-τ inversion-recovery, *G*, late gadolinium enhancement and, *H*, contrast-enhanced steady-state free precession. Colorimetric map of early T1 shortening, *I*, shows normal values (<70%). Mean myocardial early T1 shortening was 61%.

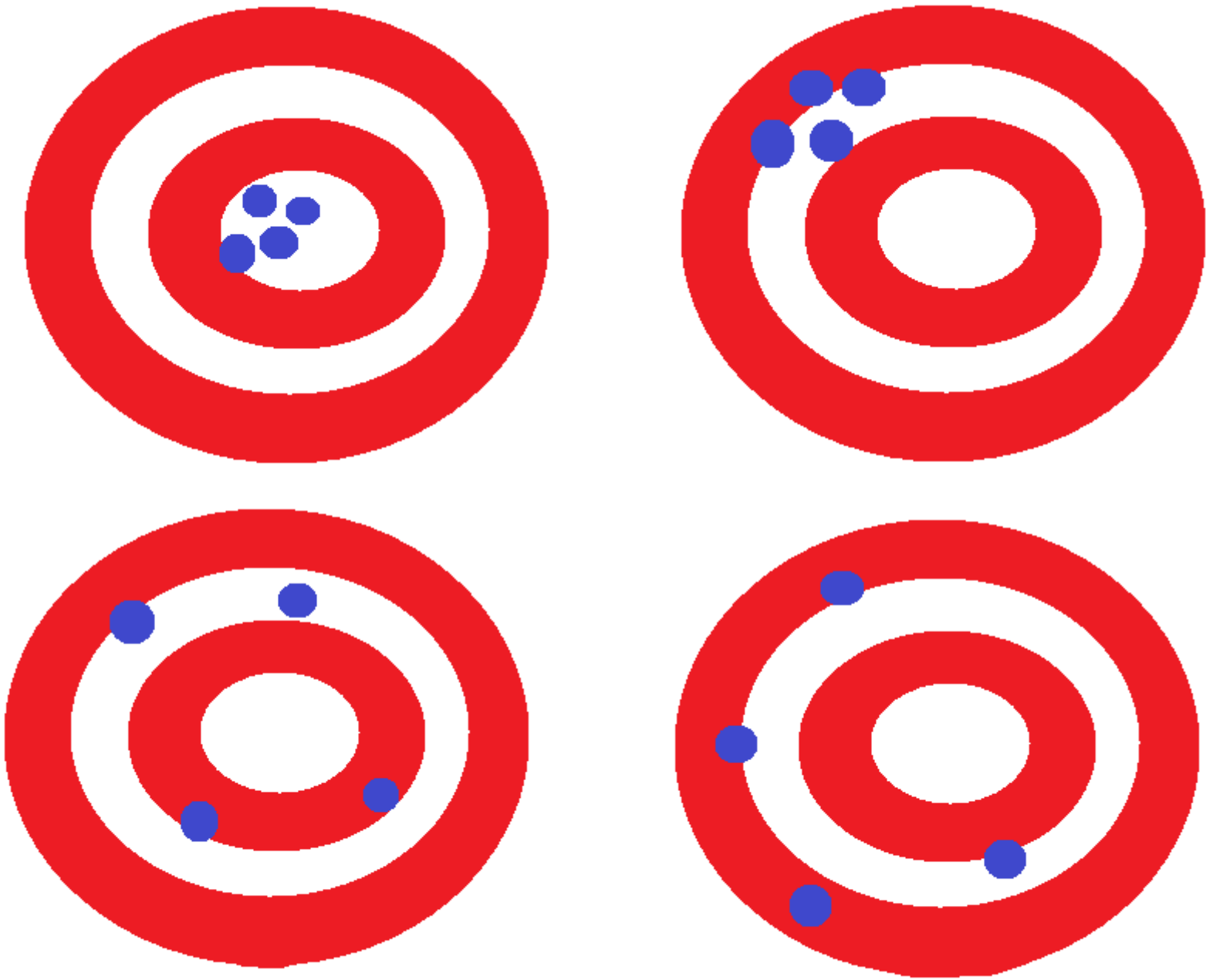


**Table 3: Diagnostic Performances of Conventional Cardiac MRI Mapping**

| Parameter | AUC* | Cut-off Value | Sensitivity | Specificity | Accuracy |
|---|---|---|---|---|---|
| Native T1 mapping (msec) | 0.93 (0.87,0.99) | >1037 | 38/45 (84) [71, 94] | 18/19 (95) [74, 100] | 56/64 (88) [77, 94] |
| T2 mapping (msec) | 0.97 (0.92,1.00) | >50 | 41/45 (91) [77, 97] | 18/19 (95) [73, 100] | 59/64 (92) [82, 97] |
| ECV (%) | 0.88 (0.80,0.96) | >26 | 37/45 (82) [68, 92] | 18/19 (95) [74, 100] | 55/64 (86) [75, 93] |

Note.—Unless otherwise indicated, data are numerators and denominators; data in parentheses are percentages, and data in brackets are 95% confidence intervals. AUC = area under curve, ECV = extracellular volume.

* Data in parentheses are 95% confidence intervals.

**Table 4: Early T1 Shortening in Participants with Acute Myocarditis and Healthy Control Participants and Diagnostic Performance in the Study Population**

| Participants with AM (%)* | HC Participants (%)* | AUC† | Cut-off Value (%) | Sensitivity‡ | Specificity‡ | Accuracy‡ |
|---|---|---|---|---|---|---|
| 75 (72−78) | 65 [61−66] | 0.97 (0.94,1.00) | ≥70 | 42/45 (93) [82,99] | 19/19 (100) [82,100] | 61/64 (95) [87,99] |

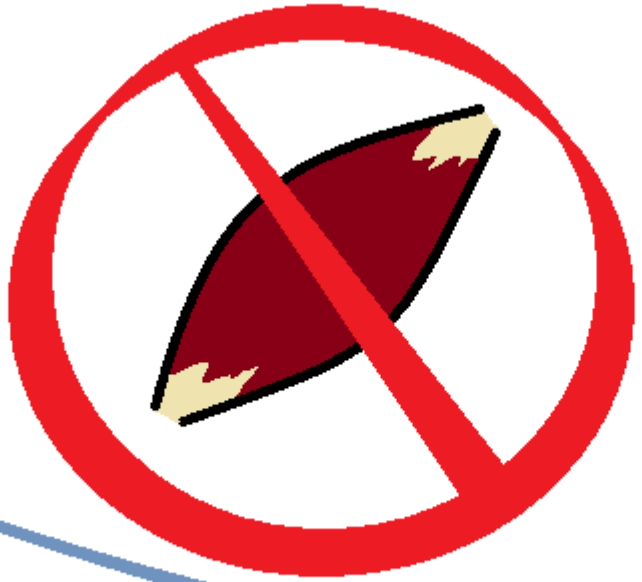
Note.—AUC = area under curve, AM = acute myocarditis, HC = healthy control.

* Data are median; data in parentheses are interquartile range.

† Data in parentheses are 95% confidence intervals.

‡ Data are numerators and denominators, with percentages in parentheses. Data in brackets are 95% confidence intervals.

S 80%
E 87%



S 93%
E 100%
Ex 95%

GRACIAS