AUTHORS' CONTRIBUTIONS

M. Lorenzo and R. de la Espriella contributed equally.

M. Lorenzo and R. de la Espriella were responsible for drafting the manuscript as well as preparing the tables and figures. I. Cardells was responsible for monitoring the patients during the study and for data collection. J.L. Górriz and A. Bayés-Genís have critically reviewed the manuscript and contributed to the correction of errors and suggestions from the reviewers. J. Núñez is responsible for devising the working hypothesis, statistical analysis and review of the different versions of the manuscript.

CONFLICTS OF INTEREST

J. Núñez has received board speaker fees and travel expenses from Novartis, Roche Diagnostics, Abbott, Rovi, Vifor Pharma, Novo Nordisk, Boehringer Ingelheim, and AstraZeneca (modest). A. Bayés-Genís has received board membership fees and travel expenses from Novartis, Roche Diagnostics, Vifor Pharma, and Critical Diagnostics (modest). The remaining authors have no disclosures to report.

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Comparison of two cardiac magnetic resonance imaging postprocessing software tools in a pig model of myocardial infarction

Comparación de dos programas de posprocesamiento de imágenes de cardiorresonancia magnética en un modelo porcino de infarto de miocardio

To the Editor,

Cardiovascular magnetic resonance (CMR) imaging has been increasingly used for testing of translational and clinical trial surrogate endpoints in cardioprotective therapies. While the JACC Scientific Expert Panel provides imaging technique recommendations and standardization[1], postprocessing and analysis methods vary institutionally. Moreover, most previous CMR postprocessing comparison and software testing data stem from human hearts. Pig hearts largely resemble their human counterparts. However, pigs have cone-shaped chests and higher resting heart rates than humans. Medis Suite (QMass MR v.3.2.60.4, The Netherlands) and CVI[42] (v.5.11, Circle Cardiovascular Imaging, Canada) are among the most widely used scanner-independent CMR postprocessing software programs. However, their interchangeability to assess anatomical and functional parameters in preclinical models has not been tested. We aimed to compare Medis Suite and CVI[42] readouts in a pig model of experimentally induced closed-chest acute myocardial infarction (MI). All procedures were authorized by the Animal Experimental Committee (#5601) of the local government.[2] We assessed anatomical and functional parameters in randomly selected 28 Landracex-Large white female pig datasets, which included baseline (before MI), early- (3 days post-MI), and late- (42 days post-MI) remodeling phase scans.[2] In addition, 25 of 28 scans included a dobutamine stress study (5-10-20-30 μg/kg/min of i.v. dobutamine at 3-minute intervals to elevate heart rate by 30-50%) using the volumetric module. To exclude interobserver- and experience-related variabilities, all images were blindly assessed by a Level 3 accredited operator. Due to animals' cardiac orientation, the quality of semi- and fully-automated ventricular contour segmentation was suboptimal in both products; thus, manual contouring was chosen.

The following were recorded: left ventricular (LV) end-diastolic volume, LV end-systolic volume, LV stroke volume, LV ejection fraction (LVEF), LV mass, right ventricular (RV) end-diastolic volume, RV end-systolic volume, RV stroke volume, and RV ejection fraction. Edema, microvascular obstruction (MVO), and necrosis mass were assessed on T_2 short-tau inversion recovery and T_1 inversion recovery sequences at early (1 minute) and late (10 minutes) gadolinium phases, respectively. On Medis Suite, we used visual assessment-defined manual planimetry on the volumetry module to draw the region(s) of interest (the late gadolinium enhancement [LGE] volume was multiplied by the myocardial density of 1.055 g/mL), and the full-width half-max (FWHM) technique, using the tissue characterization module with semiautomatic pixel value segmentation. Of note, MVO measurement on Medis Suite FWHM is planimetry-based, as the region of interest is user-defined without semiautomatic segmentation. On CVI,[42] as planimetry was unavailable for tissue characterization,

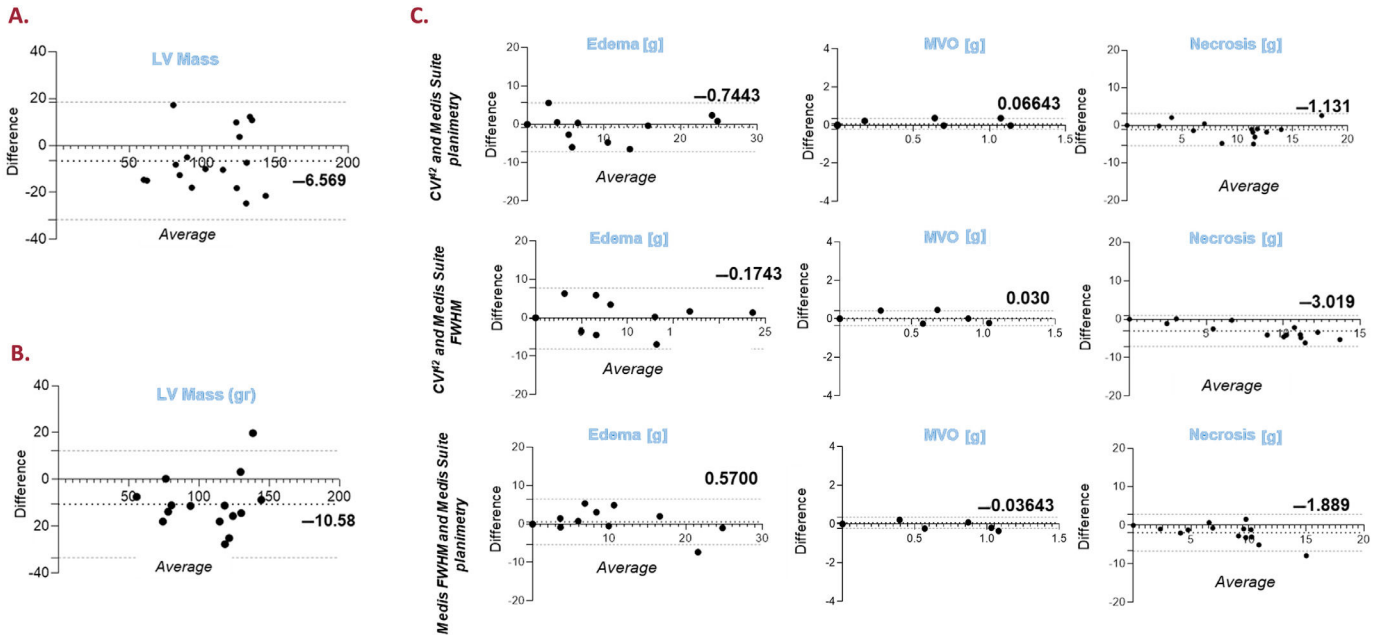

Figure 1. Bland-Altman graphs (Medis Suite-CVI[42]) vs average to analyze systematic differences at rest (A) and stress (B) of the left ventricular mass. C: Bland-Altman graphs to analyze systematic differences in the tissue characterization parameters between different methods. Dotted black lines indicate mean difference (bias; see also value in bold) and dashed grey lines indicate limits of agreement 95%. FWHM, full-width half maximum; LV, left ventricle; MVO, microvascular obstruction.

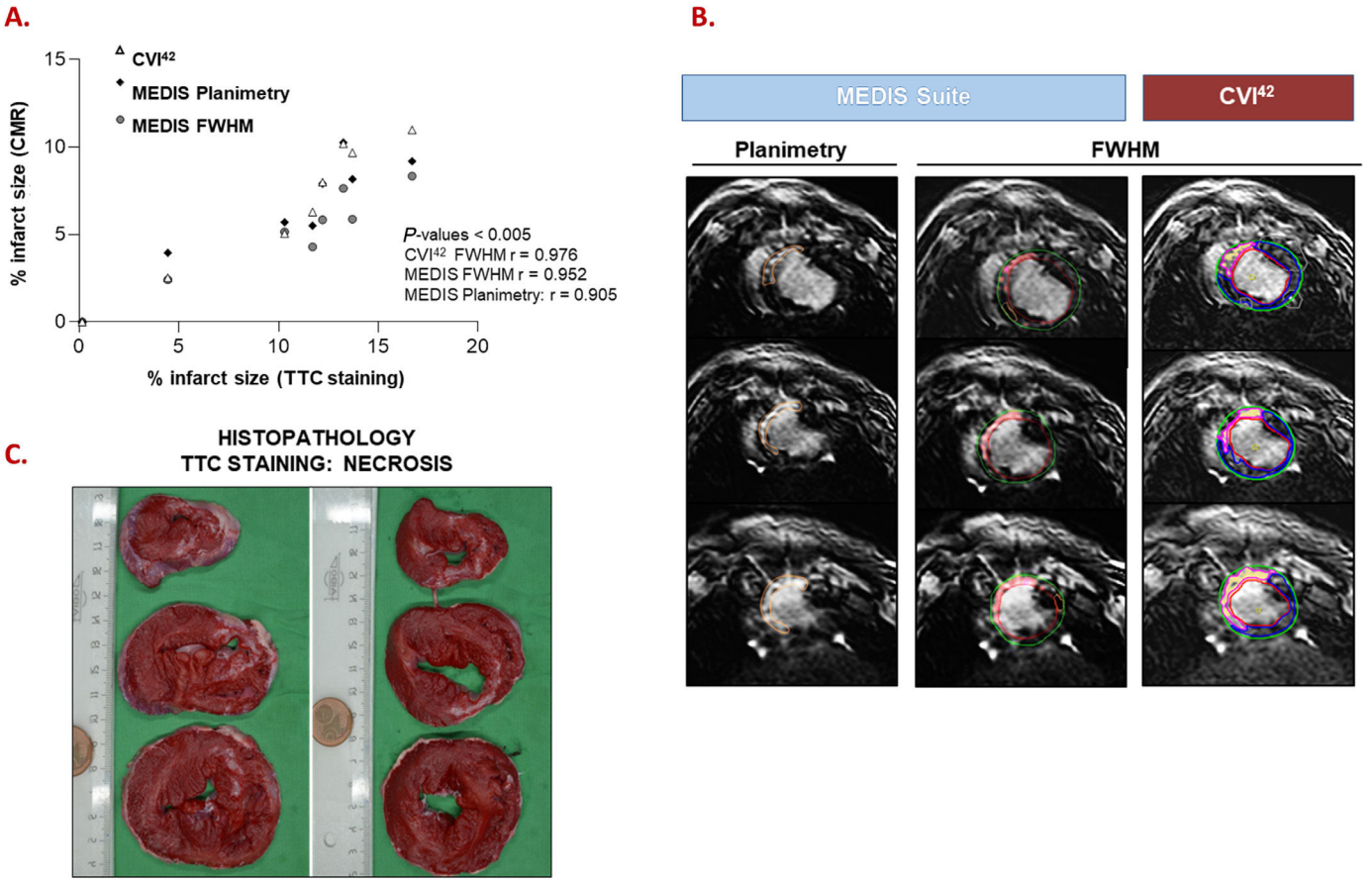

Figure 2. Correlation between the CMR-derived necrosis percentage (Medis Suite and CVI[42]) and histopathology (TTC staining) on the 8 datasets (A). Representative same-day CMR (B) and histopathology (C) images from the same animal. CMR, cardiovascular magnetic resonance; FWHM, full-width half maximum.

we used FWHM. The day 42 LGE data were correlated with infarct size assessed by triphenyl tetrazolium chloride (TTC) staining.[2]

To detect low and strong correlation variables, accepting an alpha risk of 0.05 and a beta risk of 0.2 in 2-sided tests, 28 datasets were needed to detect a correlation coefficient of 0.51. A dropout rate of 0% was anticipated. After normal distribution testing (Shapiro-Wilk), data were analyzed for correlation by the Pearson or Spearman tests, when appropriate. The Wilcoxon matched-pairs signed-rank test and the paired t-test were used to compare groups, matched as pair measurements of the same subject. For groups not following a normal distribution, equivalent nonparametric tests were performed.

The 28 datasets consisted of 3 baseline, 15 early remodeling, and 10 late remodeling phases; among the latter, 8 had histopathological analysis. Dobutamine stress was available in 25 datasets (89%). The 2 products provided similar data for biventricular volumes and LVEF, with significantly related correlation curves between measurements and Bland-Altman plots, showing only a minor systematic measurement error at rest and stress (P = nonsignificant). Only LV mass showed a mean difference of 10.58 g at stress (figure 1). The data were very similar in all structural parameters; as such, using planimetry and FMWH, we detected a high correlation between software in the necrosis, edema, and MVO quantification (P = non-significant), and Bland-Altman plots showed near-zero systematic differences for the 3 tested parameters (figure 1). LGE quantification agreed better on planimetry on Medis Suite and CVI[42] compared with FWHM on Medis Suite vs CVI[42], and planimetry vs FWHM on Medis Suite alone. FWHM on both showed a better correlation with histopathology (TTC staining) than planimetry. However, CVI[42] FWHM performed better than Medis Suite FWHM (figure 2).

Our results of volumetry comparison align with previous human data.[3] Likewise, the LV mass variability agrees with human studies,[4,5] supporting the contouring bias and suggesting that LV mass and its derivates (eg, fibrosis percentage) may be less reliable in tachycardia with hyperdynamic ventricles. While LV mass is rarely calculated under stress, the contouring variability in a hyperdynamic LV may be reduced by using the same software. As tissue characterization techniques have evolved, most CMR infarct validation studies in animal models (mainly dogs) are from the 1980s-1990s.[6] Despite different available techniques, we report good reproducibility in all 3 tissue parameters in pigs. LGE correlated best between planimetry on Medis Suite and FWHM on CVI[42]. However, direct comparison between CMR scar size and TTC staining (both performed on day 42) revealed better FWHM performance in histopathological correlation vs planimetry, particularly on CVI[42]. Small software-specific differences in semiautomatic segmentation may have contributed to this finding, indicating the need for further histopathology-validated studies for technique standardization.

In conclusion, both software tools can be used interchangeably for biventricular volumes, edema, and MVO. A single product should be considered for LV mass and necrosis follow-up. Because CMR use in experimental disease models has been increasing along with ever-evolving markers and postprocessing techniques, researchers should evaluate their postprocessing methods carefully to deliver reproducible results for a truly reliable bench-to-bedside translation.

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AUTHORS' CONTRIBUTIONS

M. Radiké: conception and design, data analysis and interpretation, manuscript drafting. S. Ben-Aicha: data analysis and interpretation; M. Gutiérrez: manuscript drafting and data interpretation. A. Hidalgo: conception and design; final manuscript approval. L. Badimon and G. Vilahur: conception and design; critical revision for important intellectual content; final manuscript approval; both authors are corresponding authors.

CONFLICTS OF INTEREST

None to declare.

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Insertion of implantable miniaturized cardiac monitors by qualified nurses in an ambulatory setting

Inserción de monitores cardiacos implantables de forma ambulatoria por personal de enfermería cualificado

To the Editor,

Major research on insertable cardiac monitors (ICMs) has focused on simplifying the insertion procedure while increasing ICM performance with more accurate detection algorithms. The marked size reduction of ICMs has allowed minimally invasive insertion in the subcutaneous tissue.[1] These improvements have opened the door for this procedure to be performed by qualified professionals such as certified nurses, which could result in more efficient time and resource management, potentially reducing waiting lists.[1]

"ICM nurse" is an ongoing multicenter, prospective, single-arm, open-label study to assess the safety and efficacy of the ICM BIOMONITOR III and IIIm (Biotronik, Germany) at 2 centers in Spain. This interim analysis presents short-term data on the feasibility of ambulatory nurse-led ICM insertions by

Table 1
Clinical and demographic characteristics and insertion data of the study participants

Variables	Nurse n = 20	Physician n = 27	*P*
Age, y	63.4 ± 10.8	74.2 ± 11.8	.002
Weight, kg,	79.4 ± 20.6	72.5 ± 11.2	.187
NYHA class[a] *(n = 46)*			.0001
I	17 (89.5)	7 (25.9)	
II	1 (5.3)	15 (55.6)	
II-III	1 (5.3)	3 (11.1)	
III	0	2 (7.4)	
ICM indication[b]			.0001
Suspected AF	1 (5.0)	2 (7.4)	
Syncope of unknown cause	7 (35.0)	6 (22.2)	
Recurrent palpitations	1 (5.0)	3 (11.1)	
Cryptogenic stroke	11 (55.0)	0	
Post-AF ablation monitoring	1 (5.0)	1 (5.0)	
Suspicion of cardiac conduction disorder	0	5 (18.5)	
Other	0	11 (40.7)	
Symptoms	7 (35.0)	20 (74.1)	.007
Syncope	5 (71.4)	6 (30.0)	
Dizziness	1 (14.3)	9 (45.0)	
Palpitations	1 (14.3)	3 (15.0)	
Dyspnea	0	2 (10.0)	
History of AF			
None	17 (85.0)	18 (66.7)	.121
Paroxysmal	3 (15.0)	4 (14.8)	
Persistent	0	5 (18.5)	
Previous AF ablation	1 (5.0)	0	.240
History of thromboembolic events or stroke			.0001
None	10 (50.0)	25 (92.6)	
Stroke	9 (45.0)	2 (7.4)	
Transient ischemic attack	1 (5.0)	0	
Comorbidities[b]			
COPD	4 (20.0)	1 (3.7)	.073