

Assessing the Utility of Using Signal-Averaged Electrocardiography as a Screening Tool for Fibrosis Detection in Cardiac Magnetic Resonance Imaging

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Introduction

- Myocardial fibrosis can contribute to ventricular arrhythmias and is a common feature in heart failure and cardiomyopathies.
- A signal-averaged electrocardiogram (SAECG) is a non-invasive test used to detect late potentials, which are manifestations of delayed myocardial depolarization with slow conduction. Late potentials often characterize cardiac fibrosis.
- Cardiac magnetic resonance imaging (cMRI) is the preferred modality for detecting fibrosis, using late gadolinium enhancement (LGE) and T1 mapping, and characterizing myocardial tissue and risk stratification for ventricular arrhythmias.
- cMRI has limitations due to limited access, time and cost concerns, and its contraindications for certain patients.
- This study explores if positive SAECGs, as defined by late potentials, correlate with the fibrosis identified in cMRI, and if negative SAECGs rule out fibrosis on cMRI, therefore assessing the utility of SAECG as a screening device and a more convenient method of risk stratification in patients at high risk for ventricular arrhythmias.

Methods

- Patients who had baseline characteristics that were suggestive of cardiomyopathies or suspected cardiomyopathies were scheduled for Cardiac Magnetic Resonance Imaging with late gadolinium enhancement (LGE) and T1 mapping for detection of fibrosis.
- SAECGs were performed on 36 patients scheduled for cardiac MRI.
- Patients with significant cMRI artifacts or a standard ECG showing a wide QRS complex (>120 ms) were excluded from data analysis.
- A positive SAECG is defined as meeting at least one of three standard abnormal criteria:
 - QRS complex ≥ 114 ms.
 - Root mean square voltage of the terminal 40 ms of the QRS complex (RMS_{40}) $\leq 20\mu V$
 - Duration of the terminal QRS complex amplitude signals $<40\mu V$ (LAS_{40}) >38 ms.
- SAECG and cMRI were then compared.

Consequences of Fibrosis

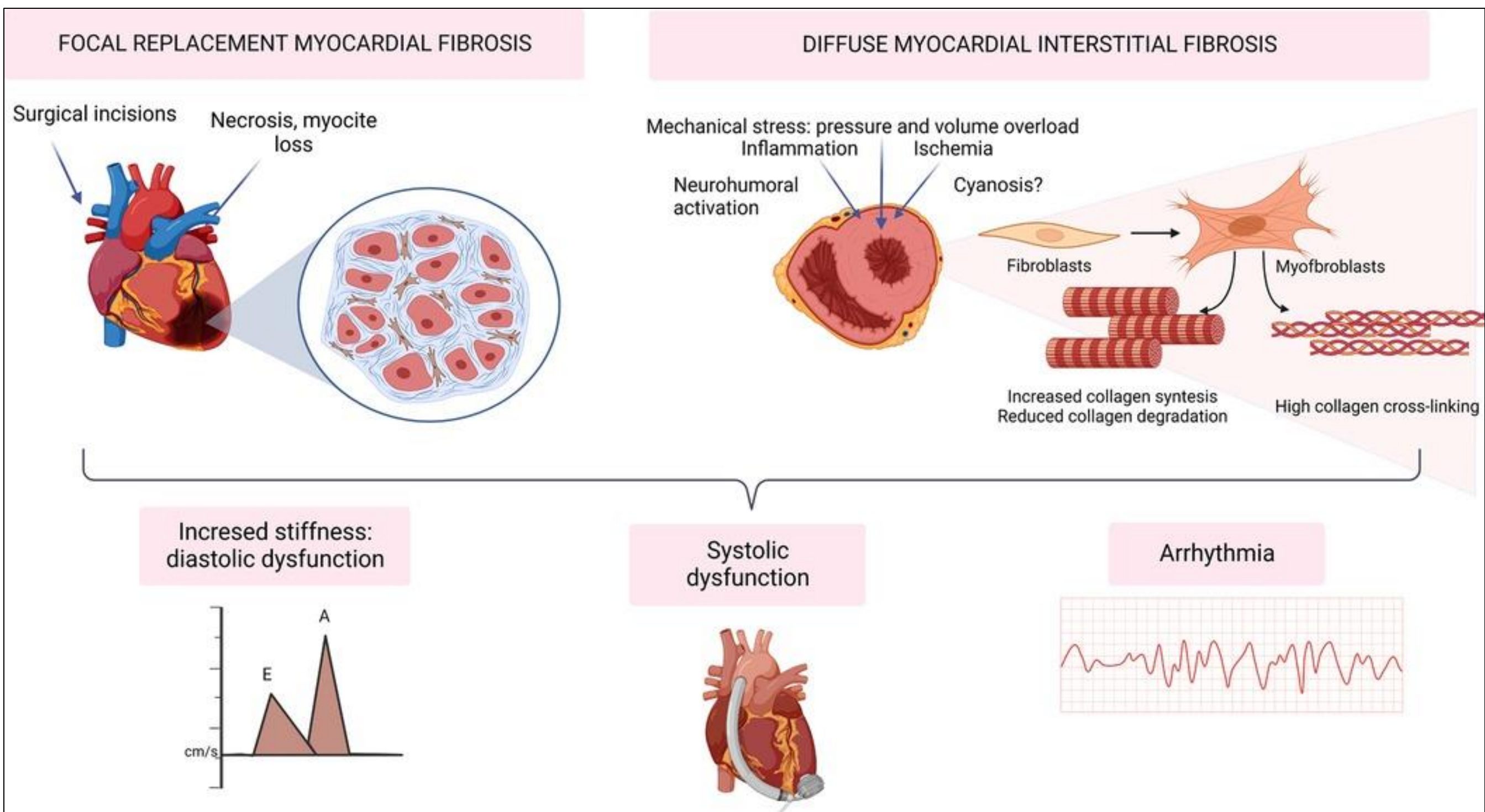


Figure 1, Diagram shows consequence of fibrosis can lead to arrhythmias.

SAECG Interpretation

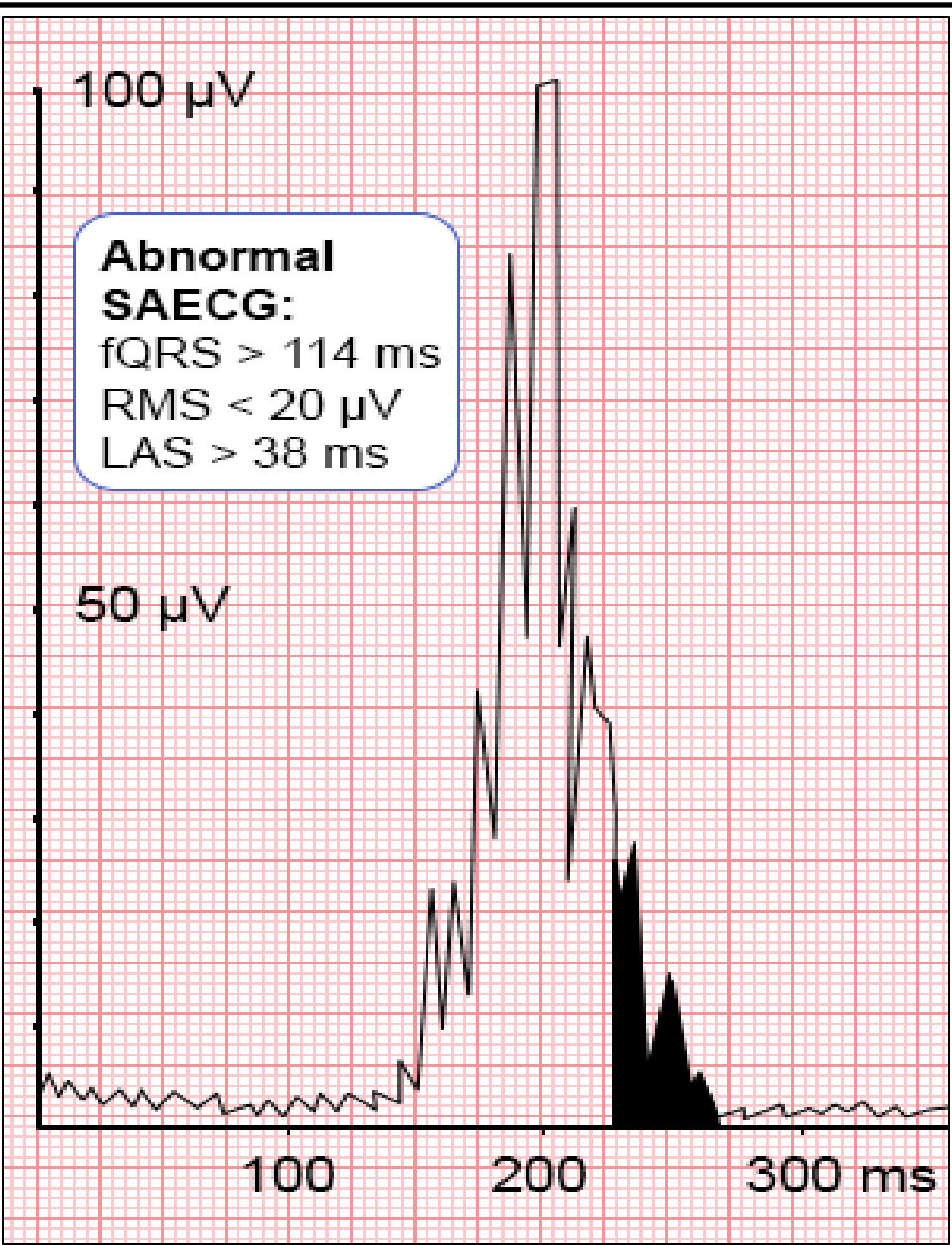


Figure 2a, example of SAECG that contains all abnormal criteria. In SAECG, signals from hundreds of QRS complexes are averaged and amplified.

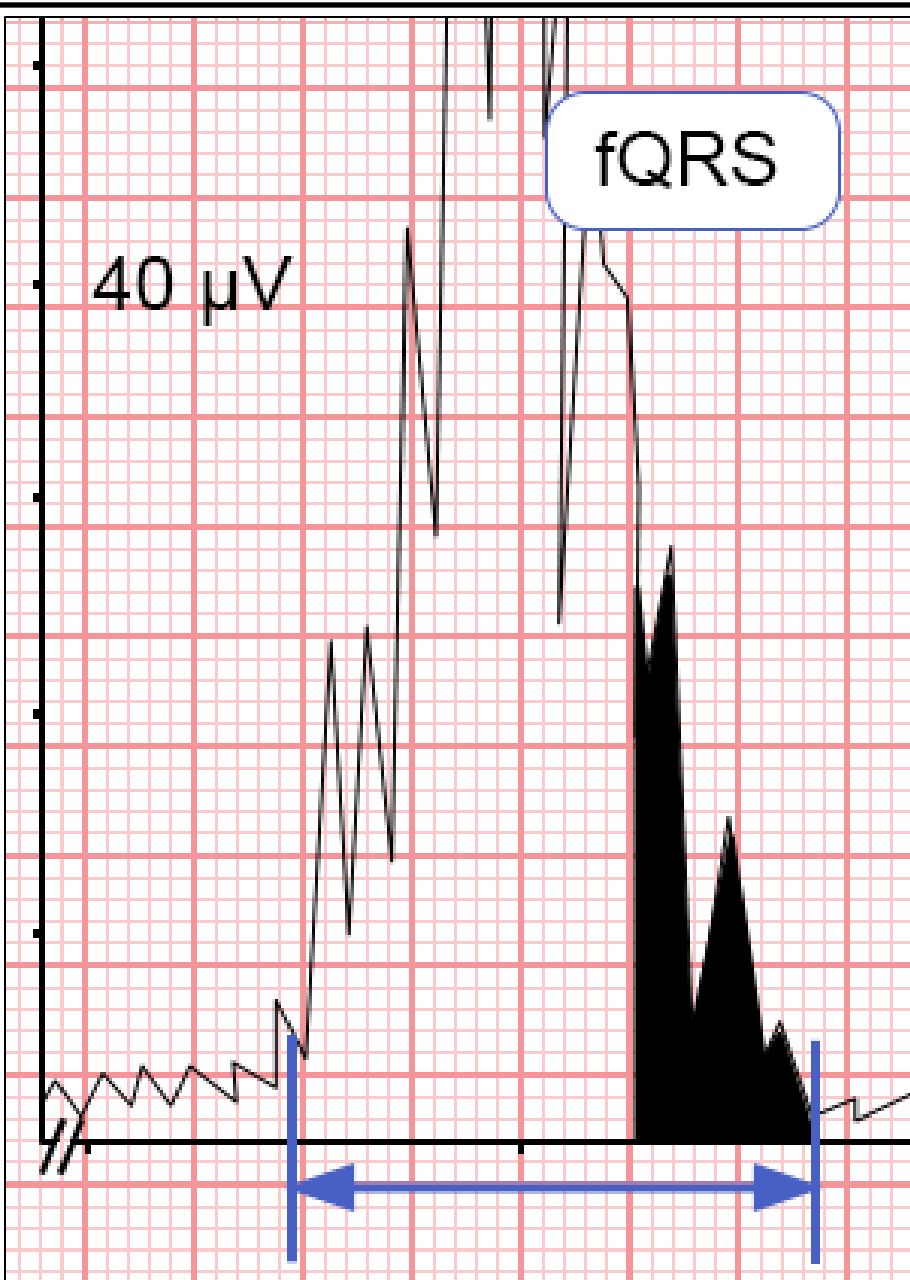


Figure 2b, displays a QRS duration ≥ 114 ms. Late potentials (shown in black) increase QRS duration.

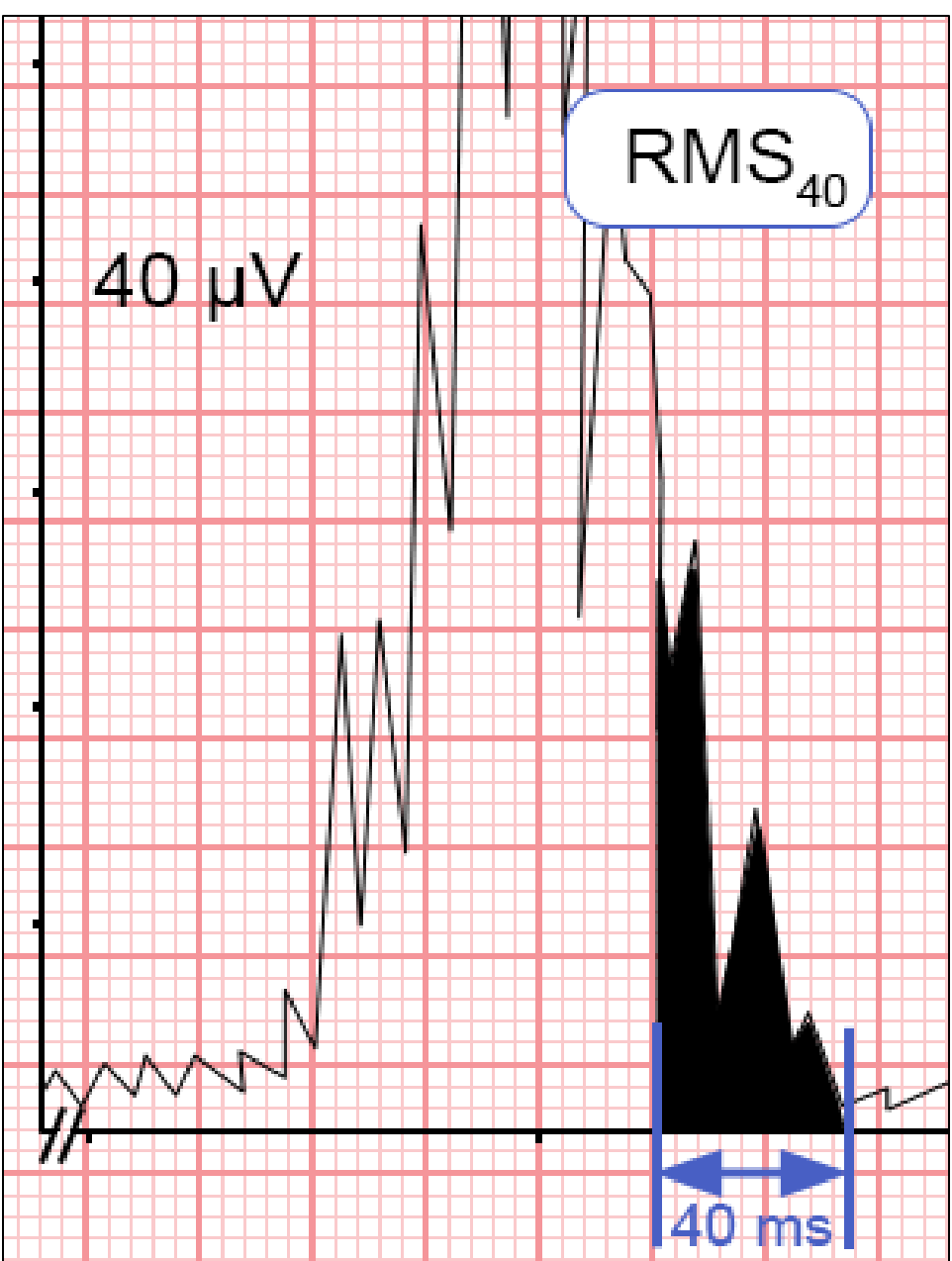


Figure 2c, displays an (RMS_{40}) $\leq 20\mu V$. (RMS_{40}) is the average size of vectors in the last 40ms of QRS. Late potentials at the end of QRS have a small (RMS_{40}) since they occur after depolarization.

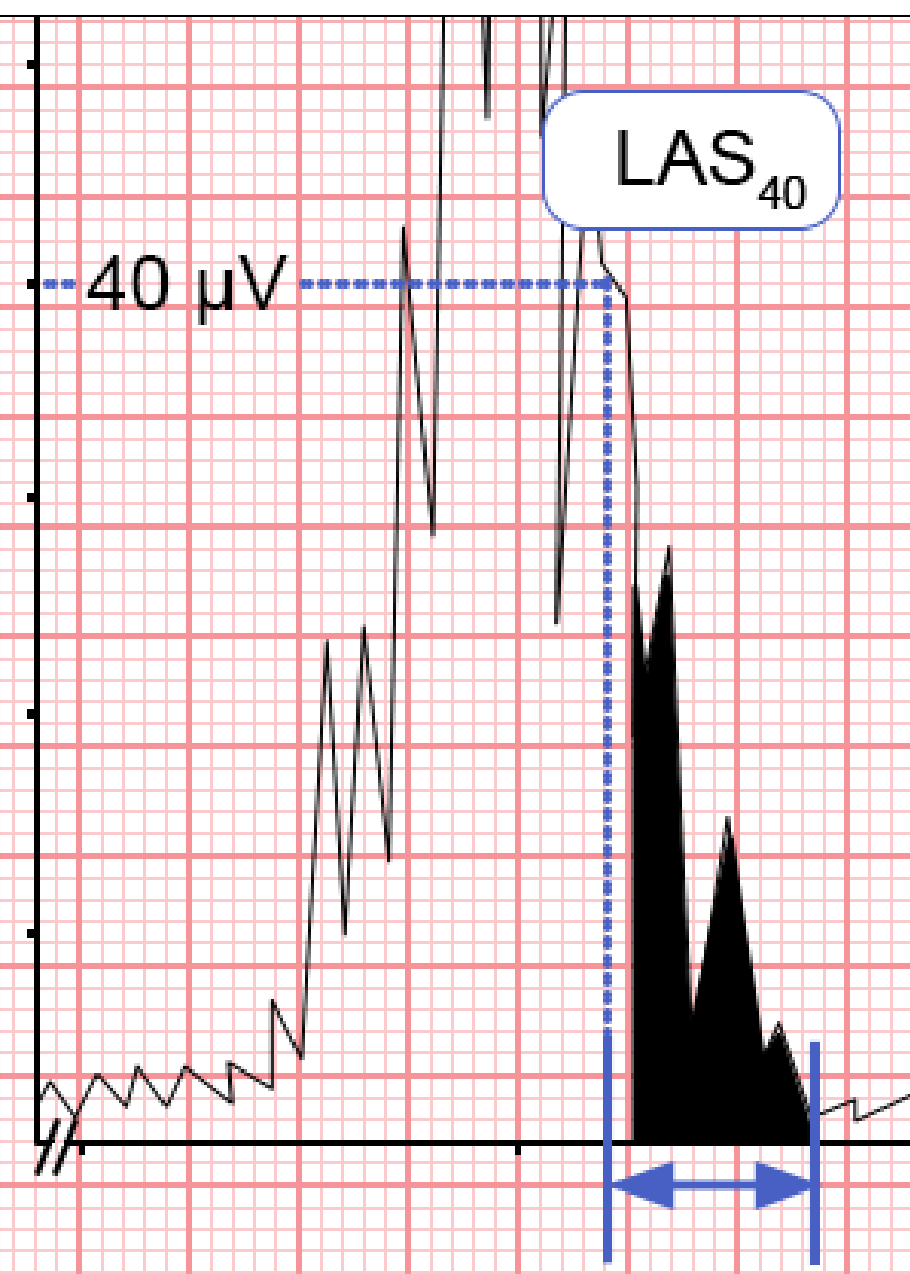


Figure 2d, displays a Low Amplitude Signal Duration $<40\mu V$ (LAS_{40}) >38 ms. Late potentials increase the duration of the terminal QRS with low amplitude.

Results

- The mean age of the patients was 50.4 years, and the mean ejection fraction was 47.7 as determined by cMRI.
- 69.23% of the patients had fibrosis on cMRI by either LGE, T1 mapping or both.
- 46.15% of patients had a positive SAECG.
- The sensitivity and specificity of SAECG were 66.67% and 100%, respectively.
- The positive predictive value (PPV) and negative predictive values (NPV) were 100% and 57.14%, respectively.
- Accuracy of SAECG is 76.92%.
- Statistical significance of sensitivity, specificity, PPV NPV, and accuracy were determined by a two-tail binomial test with the alternative hypothesis being “each of these values is not equal to 50%.”

Results	Values	P value	95% CI
Sensitivity	66.67%	0.24	(0.41- 0.87)
Specificity	100%	<0.05	(0.63- 1.00)
PPV	100%	<0.05	(0.74-1.00)
NPV	57.14%	0.79	(0.29-0.82)
Accuracy	76.92%	<0.05	(0.56-0.91)

Conclusion

- SAECG is highly specific in identifying patients with myocardial fibrosis on cMRI with a specificity of 100% with a p-value <0.05 .
- PPV of an abnormal SAECG to an abnormal cMRI is 100% with a p-value <0.05 .
- SAECG has an insignificant sensitivity (66.67% with p-value >0.05) and NPV (57.14% with p-value >0.05) indicating that this method may be a suboptimal method for risk stratification and screening since a negative SAECG does not rule out fibrosis on positive cMRI.
- A positive SAECG may better correlate with risk of ventricular arrhythmia.