Prior myocarditis and ventricular arrhythmias: The importance of scar pattern

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BACKGROUND Multiple studies have addressed the importance of anteroseptal scar in patients with nonischemic cardiomyopathy. However, this pattern has never been fully evaluated in patients with prior myocarditis.

OBJECTIVE The purpose of this study was to evaluate whether anteroseptal scar is associated with worse outcome in patients with prior myocarditis and how it affects the efficacy of catheter ablation (CA).

METHODS This was a retrospective study of consecutive patients with prior myocarditis and arrhythmic presentation. Cardiac magnetic resonance and electroanatomic voltage mapping were used to identify the scar pattern. Patients were referred for either CA or escalated antiarrhythmic drug (AAD) therapy. The main outcome was ventricular arrhythmia (VA)–free survival according to the presence of anteroseptal scar.

RESULTS A total of 144 consecutive patients with prior myocarditis were included. Mean age was 42.1 ± 14.9 years, and 58% were men. Ejection fraction was normal in 73% of patients. Anteroseptal scar was present in 44% of cases. Sixty-one patients (42%) underwent CA. Overall, at 2-year follow-up, VA-free survival was 77% in the CA group. After CA, the mean number of AADs taken by each patient decreased from 1.8 to 0.9/die ($p<0.001$). The presence of anteroseptal scar was found to be an independent predictor of VA relapse both in patients treated with CA (hazard ratio [HR] 3.6; 95% confidence interval [CI] 1.1–11.4; $P = .03$) and in the overall population (HR 2.0; 95% CI 1.2–3.5; $P = .02$) .

CONCLUSION In patients with prior myocarditis and VA, the presence of anteroseptal scar negatively predicts outcomes irrespective of treatment strategy.

KEYWORDS Anteroseptal scar; Cardiac magnetic resonance; Catheter ablation; Electroanatomic voltage mapping; Prior myocarditis; Ventricular arrhythmia

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Introduction

Patients with prior myocarditis often are young and have preserved left ventricular (LV) ejection fraction (EF).[1] Nonetheless, they experience a high rate of malignant ventricular arrhythmias (VAs) (10% per year), and the proportion of sudden cardiac deaths attributed to myocarditis at autopsy varies between <10% and 20%.[1,2] Importantly, apart from ventricular tachycardia (VT) and ventricular fibrillation, nonsustained ventricular tachycardia (NSVT) and frequent premature ventricular complexes (PVCs) are also associated with increased cardiovascular mortality in this setting.[3]

Based on current guidelines, medical therapy is the standard of care for treating arrhythmic complications of myocarditis.[4,5] However, it is not rare that medical therapy fails to control the arrhythmic burden in these patients. Previous studies demonstrated that radiofrequency catheter ablation (CA) can be effective in controlling drug-refractory VT.[6–8] Nevertheless, evidence supporting the benefit of CA mainly stems from small retrospective studies. In the absence of large comparative studies, limited data support the safety and long-term efficacy of CA in this setting.

Multiple studies have addressed the importance of anteroseptal scar in patients with nonischemic cardiomyopathy (NICM) and acute myocarditis.[1,9–12] However, this pattern has never been specifically evaluated in patients with prior myocarditis, and its impact on CA outcomes is unknown.[13–15]

This study aimed to (1) determine the predictors of VA recurrence with special focus on the underlying scar substrate; and (2) evaluate the efficacy of CA in a large cohort of consecutive patients affected by prior myocarditis with arrhythmic presentation.

Materials and methods

Study design

This study was a retrospective analysis of prospectively collected clinical data on all consecutive patients with prior myocarditis and VA referred to the electrophysiology departments of 2 tertiary referral centers for VA in Italy—Centro Cardiologico Monzino (Milan) and Policlinico Agostino Gemelli (Rome)—between 2010 and 2019.

To establish a diagnosis of prior myocarditis, all the following criteria had to be fulfilled: (1) history of endomyocardial biopsy (EMB)-proved (Dallas criteria) or cardiac magnetic resonance (CMR)-proved (Lake Louise criteria) acute myocarditis more than 12 months before the index evaluation[5,14]; (2) replacement fibrosis at EMB (when available) or presence of nonischemic late gadolinium enhancement (LGE) consistent with prior myocarditis at CMR; (3) no electrocardiographic (ECG), echocardiographic, or CMR criteria suggesting other cardiomyopathies; and (4) absence of significant coronary artery stenosis at coronary angiogram or computed tomography scan.[16–20] The presence of active myocarditis, demonstrated by EMB (leukocyte infiltration), CMR (edema), or laboratory examination (high serum troponin level) constituted an exclusion criteria.

CMR protocols for image acquisition as well as EMB protocols for histologic processing are given in Supplemental Appendixes 1 and 2.

VA was defined as the presence of ventricular fibrillation, sustained VT, symptomatic NSVT/frequent PVCs (>10,000/10%/die), or asymptomatic NSVT/PVCs presumed to cause ventricular dysfunction. Antiarrhythmic medications were defined in accordance with the Vaughan Williams classification.[21]

All patients who satisfied the diagnostic criteria for prior myocarditis and had VA were included in the analysis. Upon clinical indication and based on current guideline recommendations, patients were referred for either CA (CA group) or escalated antiarrhythmic drug therapy (AAD group).[3–5] Specifically, patients referred for CA were those with monomorphic VA and those in whom AAD was not tolerated, contraindicated, or already at its maximal dosage. The CA protocol is given in Supplemental Appendix 3. All EMB procedures were guided by endocavitary electroanatomic voltage mapping (EVM) acquired with the CARTO (Biosense Webster) or NavX (Abbott) system. EVM allows for 3-dimensional cardiac chamber reconstruction and recording of intracardiac ECGs. These combined data are represented on an EVM on which it is possible to localize areas of low voltage representing diseased tissue. The EMB protocol is extensively discussed in Supplemental Appendix 4.[22]

The study protocol conforms to the ethical guidelines of the Declaration of Helsinki. All patients provided informed consent for all tests and procedures performed during hospitalization. The study protocol was approved by the Centro Cardiologico Monzino and Policlinico Agostino Gemelli Ethics Committee.

Scar characterization

Scar pattern was classified according to CMR evaluation with LGE when available and unipolar and bipolar EVM in the remaining cases. Two distinct scar patterns were identified: those with anteroseptal involvement (S+) (at least >30% of anteroseptal segments involved) and those without anteroseptal involvement (S–). Examples of anteroseptal scar and inferolateral scar are shown in Figures 1 and 2. The 2 groups (S+ and S–) were compared for baseline characteristics, procedural data, and primary and secondary endpoints at long-term follow-up.

Follow-up and outcomes

After hospital discharge, follow-up was performed, consisting of outpatient visits every 6 months and 24-hour Holter ECG monitoring scheduled at 3, 6, and 12 months, and every 6 months thereafter. Patients with an implantable cardioverter-defibrillator (ICD) were reviewed every 6 months to retrieve stored ICD electrogram information. When longitudinal office follow-up visits were not available, telephone interviews were performed. Long-term outcomes included (1) survival free from any VA; and (2) mortality.

VA recurrence was defined as the recurrence of the index VA or of any sustained VA. Relationships between the treatment strategy and outcomes were analyzed. Additionally, predictors of VA recurrence (with special attention to scar pattern) were investigated.

Statistical analysis

Continuous variables are given as mean ± SD when normally distributed or as median (interquartile range) when non-normally distributed. Accordingly, comparison between groups was made using the parametric (Student *t* test) or nonparametric (Mann-Whitney *U* test) test, respectively. Categorical variables are given as absolute value and percentage. Comparison between categorical variables was performed using the χ^2 test and the Fisher exact test, as indicated. Event-free survival was estimated by the Kaplan-Meier method using the log-rank test. Univariate Cox proportional hazard analysis assessed the relationship between baseline characteristics and procedural data with respect to arrhythmia recurrence. SPSS 23.0 (IBM Corp., Armonk, NY) was used for all statistical analyses. $P < .05$ for a 2-tailed test was considered significant. Confidence intervals (CIs) were set at 95%.

Results

Baseline characteristics

The final study population consisted of 144 patients (71 from Policlinico Agostino Gemelli and 73 from Centro Cardiologico Monzino). Baseline patient characteristics are summarized in Table 1. Mean patient age was 42.1 ± 14.9 years, and 83 (57.6%) were male. The diagnosis of prior myocarditis was confirmed by EMB in 112 patients (77.8%). Forty-eight patients (35.8%) already had an ICD. Before ablation, antiarrhythmic therapy consisted of a mean of 1.63 ± 0.56 AADs; 46 (42.2%) were taking amiodarone and 85 (78.0%) were taking beta-blockers (Supplemental Figure S1 and Supplemental Table S1).

Seventy-three percent of patients had normal LV EF, and only 11 (7.6%) had EF <35%. According to pooled CMR and EVM evaluation, a pathologic substrate was identified in the anteroseptal region in 64 patients (44.4%). Among these 64 patients, the diagnosis of prior myocarditis was confirmed by EMB in 55 (85.9%). EVM- and CMR-specific results are given in Supplemental Figure S2.

The VAs for which patients were referred are listed in Table 1. The cumulative arrhythmic burden of the patients is given in Supplemental Table S2. Patients referred for CA were more often affected by VT, whereas patients referred because of resuscitated sudden cardiac death or ICD shock were more frequently managed with medical therapy (Supplemental Figure S3D). One-third of the patients affected by PVCs who were included in the study were referred because of suspicion of PVC-induced cardiomyopathy (low EF) superimposed on prior myocarditis. The remaining patients were referred because of symptoms. Additionally, patients in the CA group took more AADs at baseline (1.76 vs 1.45; $P = .008$), especially amiodarone (58.2% vs 25.9%, $P = .001$) and Class IC AADs (26.8% vs 6.6%, $P = .005$) (Supplemental Table S1). Conversely, the 2 groups were homogeneous with regard to clinical characteristics, imaging data, and EVM analysis (Table 1).

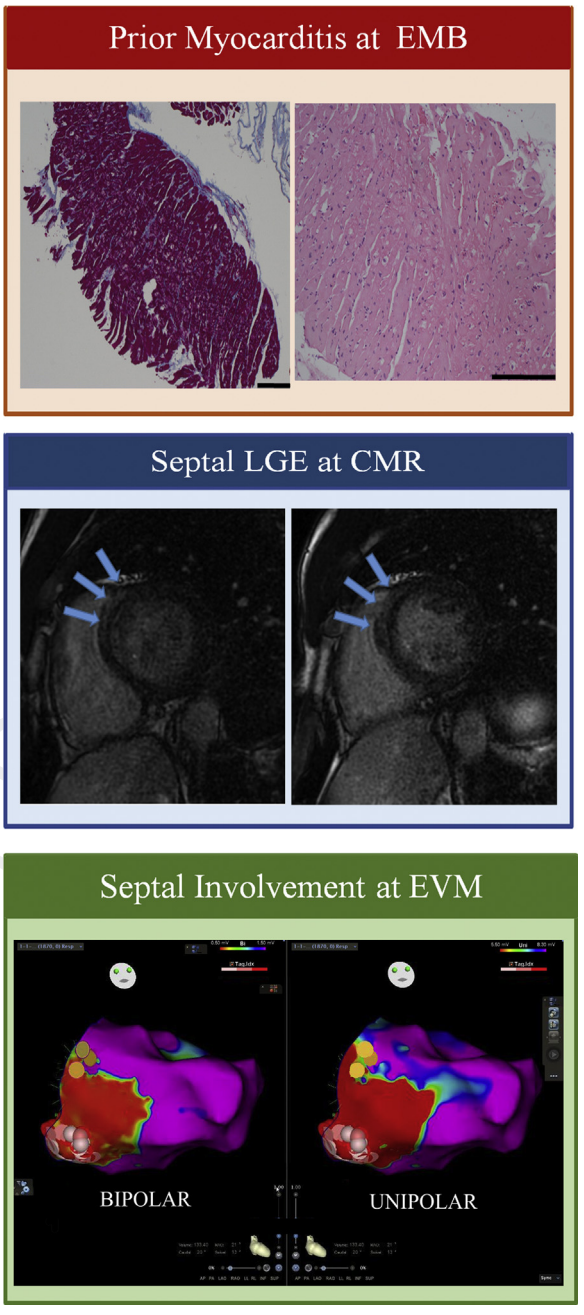

Figure 1 Anteroseptal scar. **Top:** Endomyocardial biopsy (EMB). Samples obtained from septum. **Left:** Masson trichrome staining shows spots of substitutive fibrosis and areas of damaged, possibly necrotic, cardiomyocytes (*light red*). **Right:** Hematoxylin-eosin staining shows cardiomyocytes of variable dimensions (between 15 and 21 μm), occasionally presenting perinuclear aloes, and cytoplasmic vacuolization. **Middle:** Cardiac magnetic resonance (CMR). Short-axis view of left ventricle shows septal hyperintensity signal on late gadolinium enhancement (LGE) images (*arrows*). **Bottom:** Endocardial electroanatomic voltage mapping (EVM). Data from a patient with anteroseptal scar showing (from **left** to **right**) endocardial bipolar and unipolar 3-dimensional EVM. *Yellow dots* represent the His and conduction system. *White to red dots* represent ablation sites.

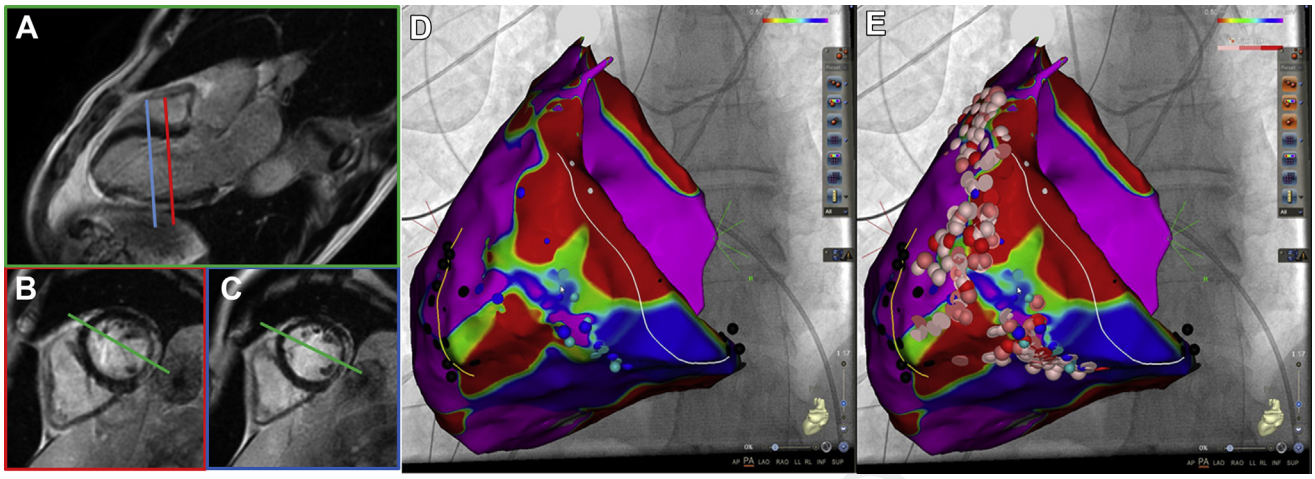

Figure 2 Inferolateral scar. **A–C:** Cardiac magnetic resonance long-axis **(A)** and short-axis **(B, C)** views show hyperintensity signal on left ventricular posterolateral wall, suggestive of previous myocarditis. **D, E:** Epicardial bipolar voltage mapping (posteroanterior views) merged with fluoroscopy before **(D)** and after **(E)** catheter ablation. *Black dots* represent phrenic nerve. *Blue* and *light-blue dots* represent late and fragmented potentials. *White to red dots* represent ablation sites on the scar border.

Procedural findings

After clinical and invasive assessment, 61 patients (42.4%) underwent CA: 43 (70.5%) by an endocardial-only approach and 18 by an endocardial and adjunctive epicardial approach. The epicardial approach was used only in cases of sustained VT and NSVT ablation (42 procedures), corresponding to 42.8% of all VT ablation procedures. Procedural data are given in Supplemental Table S3. Following CA, the number of AADs (particularly amiodarone) was reduced significantly and was lower in the CA than the AAD group (0.93 vs 1.70; *P*

Table 1 Baseline characteristics of the general population according to management strategy

	Total (N = 144)	AAD (n = 83 [57.6%])	CA (n = 61 [42.4%])	*P* value
Age (yr)	42.1 ± 14.9	41.6 ± 15.1	42.7 ± 14.3	.65
Male sex	83 (57.6)	48 (57.8)	37 (60.7)	.73
EMB diagnosis of prior myocarditis	112 (77.8)	62 (74.7)	50 (81.9)	.68
Previous ICD implant	48/134 (35.8)	25/73 (34.2)	23 (37.7)	.68
PVCs	48 (33.3)	33 (39.8)	15 (24.6)	.07
NSVT	28 (19.4)	18 (21.7)	10 (16.4)	.52
Sustained VT	36 (25.0)	4 (4.8)	32 (52.5)	**<.001**
ICD shocks or VF	32 (22.2)	28 (33.7)	4 (6.6)	**<.001**
LV EF (echocardiography)	52.9 ± 13	52.6 ± 13.8	53.4 ± 12.0	.74
LV EF <50%	39 (27.1)	22 (26.5)	17 (40.1)	.10
LV EF <35%	11 (7.6)	7 (8.4)	4 (6.6)	.68
CMR	104 (72.2)	67 (80.7)	37 (60.7)	**.008**
RV EDVi (mL/m^2)	92.3 ± 30.1	94.8 ± 20.9	102.3 ± 22.8	.33
LV EDVi (mL/m^2)	113.9 ± 40.3	115.9 ± 46.4	110.7 ± 28.5	.68
RV EF	52.2 ± 10.2	52.6 ± 10.5	51.4 ± 9.7	.57
RV <50%	33 (32.4)	21 (30.9)	12 (35.3)	.65
LV EF	51.4 ± 11.7	52.1 ± 12.3	49.8 ± 10.1	.33
LGE	79 (75.9)	51 (76.1)	28 (75.6)	.06
Anteroseptal scar (CMR)	38 (36.5)	22 (32.8)	16 (43.2)	.88
Anteroseptal scar (EVM)	50 (39.1)	27 (35.5)	23 (43.4)	.25
Anteroseptal scar (EVM and CMR)	64 (44.4)	37 (44.6)	27 (44.3)	.97
EVM	**129 (89.6)**	**76 (91.6)**	**53 (86.9)**	**.36** Q9
Unipolar scar (cm^2)	28 (10.0–67.7)	27.0 (10.0–75.9)	41 (12.0–61.9)	.42
Unipolar scar (%)	12.5 (4.7–34.9)	11.6 (4.4–35.9)	17.3 (4.8–26)	.31
Bipolar scar (cm^2)	12.9 (4.7–25.1)	14.5 (4.2–22.7)	10.3 (4.9–28.9)	.75
Bipolar scar (%)	6.4 (2.4–13.4)	6.6 (2.3–15.4)	6.2 (2.3–11.9)	.396

Values are given as mean ± SD, n (%), or median (interquartile range) unless otherwise indicated. Cutoff values for dilation were referred to international standards.

AAD = antiarrhythmic drugs; CA = catheter ablation; CMR = cardiac magnetic resonance; EDVi = end-diastolic volume index; EF = ejection fraction; EMB = endomyocardial biopsy; EVM = electroanatomic voltage mapping; ICD = implantable cardioverter-defibrillator; LGE = late gadolinium enhancement; LV = left ventricle; NSVT = nonsustained ventricular tachycardia; PVC = premature ventricular complex; RV = right ventricle; VF = ventricular fibrillation; VT = ventricular tachycardia.

Table 2 Predictors of arrhythmic relapse in patients treated with CA

	Univariate analysis		
	HR	95% CI	*P* value
Arrhythmia at presentation			
PVC	0.96	0.27–3.4	.95
NSVT	0.71	0.16–3.15	.63
Sustained VT	0.92	0.33–2.53	.87
VF or aborted sudden death	2.44	0.53–11.2	.25
Imaging data			
Reduced LV EF (<50%)	1.50	0.45–4.92	.508
Reduced LV EF (<35%)	**6.33**	1.25–31.90	**.025**
Anteroseptal scar	**3.60**	1.14–11.39	**.029**
LGE+	2.04	0.71–5.85	.19
Procedural data			
Endocardial-epicardial procedure	1.16	0.36–3.71	.80
VT inducibility	**0.10**	0.02–0.55	**.007**
VT noninducibility after CA	0.51	0.09–2.68	.43

Cox proportion univariate and multivariate hazard analysis for predictors of VA-free survival in patients who underwent CA.

CI = confidence interval; HR = hazard ratio; other abbreviation as in Table 1.

= .003) (Supplemental Table S1). During the index hospitalization, 10 more patients underwent ICD insertion.

Anteroseptal vs nonanteroseptal scar

Baseline characteristics of patients with and those without anteroseptal involvement referred for CA were not significantly different with regard to clinical characteristics, arrhythmic presentation, imaging, and EVM data (Supplemental Table S4). Patients without anteroseptal involvement more frequently underwent epicardial mapping/ablation (P = .025) (Table 2). Of note, CA acute procedural success (noninducibility) was similar for S+ and S– patients (81.8% vs 75.0%, respectively; P = .66).

Long-term follow-up

The percentage of patients who successfully underwent adequate follow-up at 3, 6, 9, and 12 months was 95.1%, 90.3%, 84.0%, and 77.8%, respectively. During median follow-up of 24.5 months (11.1–68.5), 51 patients (39.8%) experienced VA recurrence. In the CA group, VA-free survival at 1, 2, and 3 years was 87%, 77%, and 70%, respectively. In patients treated medically, VA free-survival was 68%, 58%, and 53%, respectively (Figure 2). During median follow-up of 26.9 months (15.9–91.6), 6 patients died, with mortality of 2% at 1 year and 4% at 2 years. There were no significant differences between the 2 groups (log-rank P = .56).

Analyzing predictors of VA recurrence in patients undergoing CA, reduced LV function (LVEF <35%) (hazard ratio [HR] 6.33) and anteroseptal scar location (HR 3.60) was shown to be an independent predictor of arrhythmic relapse on univariate analysis (Table 2 and Figure 3A). With regard to predictors of VA recurrence in the overall population, reduced EF and anteroseptal scar were associated with arrhythmic relapse (HR 7.24 and 2.02, respectively), whereas CA conferred lower risk (HR 0.5) (Figure 3B and Table 3). Sudden cardiac death or ICD shock at presentation were also associated with higher risk of recurrence (HR 2.0) (Supplemental Figure S3A). Considering only patients referred for VT ablation, the presence of anteroseptal scar was associated with a trend toward higher recurrences, although this did not reach statistical significance (Supplemental Figure S3E).

Procedural complications

A total of 6 procedural complications (9.8%) occurred. Three patients developed vascular access–related complications. Specifically, 2 patients developed arteriovenous fistula, without hemodynamic impact, and were managed conservatively. One patient developed femoral pseudoaneurysm requiring surgical repair. Two patients developed pericardial effusion without signs of tamponade and were managed with anti-inflammatory drugs. One patient developed liver hematoma and retroperitoneal hemorrhage secondary to pericardial puncture. He underwent abdominal surgery and recovered well. Full data are given in Supplemental Table S5.

Discussion

Main findings

This study describes the largest cohort of patients with prior myocarditis and VA reported to date. One of the major strengths of our study is the high number of EMBs performed. Prior myocarditis was EMB-proven in nearly 80% of cases, which give us high confidence when ruling out phenocopies such as idiopathic dilated cardiomyopathy and arrhythmogenic cardiomyopathy. The main findings of the study are as follows. (1) Irrespective of the treatment strategy (AAD or CA), we report a worse outcome in patients with anteroseptal scar, consistent with the results of previous studies analyzing patients with NICM and acute myocarditis. (2) In adequately selected patients, CA of VA in patients with prior myocarditis is a safe and effective approach to achieve long-term arrhythmia control. Our findings confirm and extend the results of previous studies showing how CA provides good long-term outcomes.[8] (3) CA allowed achievement of good arrhythmic control with limited use of AADs, especially amiodarone, which was discontinued in 65.6% of patients. This is a particularly attractive goal considering the young age of our patients.

Prior myocarditis: A specific subtype of NICM

Data on VA ablation in patients with myocarditis are scarce.[1,7,8,23–27] These patients often are reported under the broader category of NICM. Patients labeled as having NICM encompass a heterogeneous cohort.[28,29] Different etiologies are associated with different arrhythmic substrates, markedly variable outcomes, and different long-term clinical implications.[1,30] Patients with prior myocarditis represent a small (6%) but significant percentage of such patients.[30]

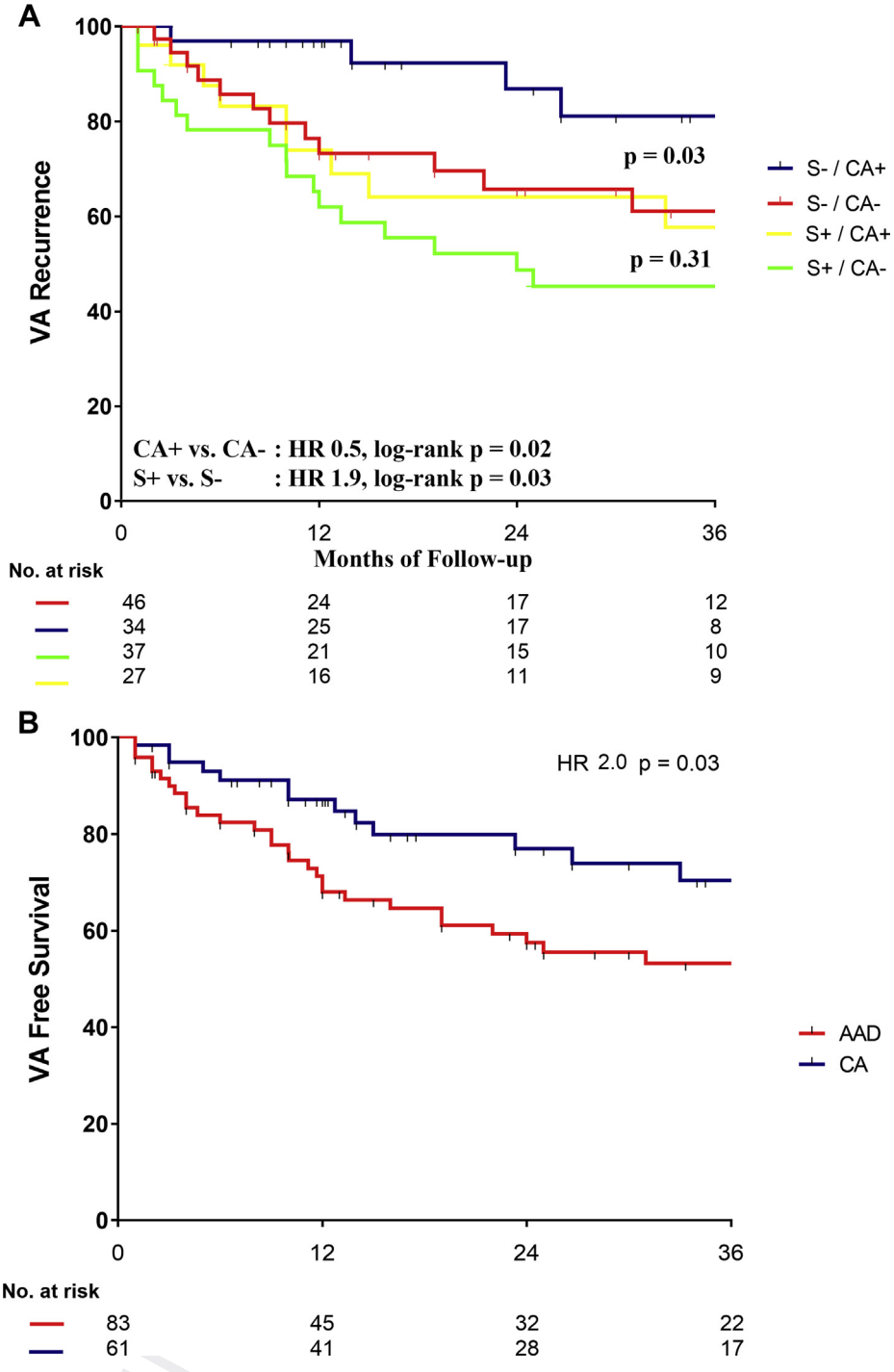

Figure 3 **A:** Kaplan-Meier curve shows how catheter ablation (CA) was superior to escalated antiarrhythmic drug therapy (AAD) in patients without septal scar (S–) (hazard ratio [HR] 0.3; log-rank $P = .03$) but not in those with anteroseptal involvement (S+) (HR 0.7; log-rank $P = .31$). Overall, patients with S+, irrespective of management strategy, had a higher recurrence rate on multivariate analysis (HR 1.9; log-rank $P = .03$). **B:** Kaplan-Meier survival curve shows ventricular arrhythmia (VA)-free survival in the overall population, stratified by treatment strategy: CA or medical therapy (ADD). CA seemed superior to AAD (HR 0.502 [0.274–0.918]; $P = .025$).

Compared to the majority of patients with NICM, those with myocarditis differ in 2 important aspects. First, they often have preserved EF, as confirmed in our cohort of patients.[27] Second, the long-term outcome of postmyocarditis patients is better than in those wits other NICMs (eg, valvular cardiomyopathy, sarcoidosis, hypertrophic cardiomyopathy).[30] Our results are in line with previous small cohort studies reporting 10% to 25% VA recurrence during median follow-up of 23–28 months for patients with myocarditis.[27–30]

Of note, the 2019 HRS/EHRA/APHRS/LAHRS (Heart Rhythm Society/European Heart Rhythm Association/Asia

Table 3 Predictors of arrhythmic relapse in the overall population

	Univariate analysis		
	HR	95% CI	*P* value
Clinical presentation			
PVC	0.90	0.50–1.63	.74
NSVT	1.04	0.53–2.04	.91
Sustained VT	0.95	0.24–1.07	.08
Syncope or aborted sudden death	**2.0**	1.11–3.64	**.02**
Imaging data			
Reduced LV EF (<50%)	1.83	0.99–3.39	.053
Reduced LV EF (<35%)	**7.24**	3.24–16.19	**.001**
Anteroseptal scar	**2.02**	1.15–3.54	**.015**
LGE	1.72	0.96–3.06	.068
Catheter ablation	**0.50**	**0.27–0.92**	**.025**

Cox proportion univariate and multivariate hazard analysis for predictors of VA-free survival in the overall population.

Abbreviations as in Tables 1 and 2.

Pacific Heart Rhythm Society/Latin American Heart Rhythm Society) Expert Consensus Statement on Catheter Ablation of Ventricular Arrhythmias and previous European and American guidelines did not specifically address the issue of VA ablation in patients with prior myocarditis. They simply recommend supportive therapy in the acute phase, and antiarrhythmic drugs and ICD insertion in cases of VA persistence.[3,4,31] The absence of specific indications reflects the lack of high-quality evidence on this issue.[8,24,25,27] The cumulative evidence arising from previous studies and from our own supports the concept that, in selected patients (ie, with refractory monomorphic VA at baseline and without anteroseptal scar), CA may be effective in achieving VA-free survival.

Importance of scar pattern

In our analysis, the location of the scar detected via LGE at magnetic resonance imaging and EVM was paramount in defining ablation success. Different scar locations and scar amounts carry different prognoses.[12] In particular, in patients with NICM, 2 major categories are recognized: anteroseptal scar and nonseptal substrate with predominant basal inferolateral scar.[9,32,33] S+ is more often transmural than S–, which usually is subepicardial.[33] However, the concept of scar location in patients with prior myocarditis undergoing CA of VA has never been specifically addressed. Interestingly, acute procedural success (noninducibility) was similar for S+ and S– patients, whereas the rate or recurrence was 37% vs 13%, respectively, at 2 years ($P = .03$). These results are in line with a previous study from Oloriz et al[9] of patients with NICM.[33] For the first time, even in patients with prior myocarditis, our data support the notion that anteroseptal involvement of the arrhythmic substrate confers upon patients, irrespective of the treatment strategy, a high recurrence rate and poor procedural success. Specifically, in-depth localization of the critical isthmus is being sought as the main cause of the poor success of conventional unipolar CA. Alternative approaches (eg, alcohol ablation, bipolar ablation, radiotherapy) are under evaluation.[34] Our findings suggest that optimal patient selection is a cornerstone for VT ablation success in patients with prior myocarditis.

With regard to clinical management of these patients, it is interesting to consider a recent paper by Simon et al[12] analyzing the long term-follow-up (10 years) of 183 biopsy-proven cases of viral myocarditis. They confirmed that the presence of LGE in the anteroseptal segments was associated with higher mortality; however, they did not provide the mechanism behind the increased rate of death. The answer can instead be found in our study, as the increased rate of malignant VAs may explain, with longer-term follow-up, the higher mortality rate. Overall, although prospective data are lacking, the present body of evidence supports a more cautious management of patients with anteroseptal scar, with close follow-up. In addition, when in doubt about ICD insertion, this pattern might be taken into consideration.

Interestingly, in our population, anteroseptal scar was present in 44% of patients, which is slightly higher than in previously reported studies (36%).[10–12] However, it has to be noted that anteroseptal involvement is associated with higher arrhythmic burden. If we consider that only patients referred for VA were enrolled, this explains the higher prevalence of anteroseptal involvement in our population.

Study limitations

Our study was retrospective, so proper comparison between the 2 management strategies (AAD and CA) is limited by selection bias. Indeed, our aim was to show the recurrence rate in each subgroup and not to compare 2 different strategies. We wanted to focus on real-world patients with a wide variety of VAs and to understand how, despite receiving best guideline-directed medical treatment, the scar pattern influenced outcome. Additionally, we report data from 2 specialized tertiary referral centers for VT ablation, so results may not be applicable to all institutions.

We expected use of the epicardial approach to improve VA-free survival. The fact that this finding did not emerge from our study may be secondary to the limited statistical power of the study.

With regard to follow-up, an ascertainment bias is present, as patients with an ICD were more subject to asymptomatic VA detection than patients who underwent Holter ECG monitoring. However, the number of patients with an ICD was not different between the 2 groups.

Conclusion

In a large cohort of patients with prior myocarditis and VA, anteroseptal scar was independently associated with VA recurrence, irrespective of the treatment strategy (medical therapy or CA). In adequately selected patients, CA conferred good VA-free survival at 2-year follow-up (77%) with limited need for AADs. Our findings suggest that optimal patient selection is a cornerstone for VT ablation success in patients with prior myocarditis.

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Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrthm.2020.12.016.

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