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Rademaker, R.; Riva, M. de; Piers, S.R.D.; Wijnmaalen, A.P.; Zeppenfeld, K.

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ORIGINAL RESEARCH

VENTRICULAR TACHYCARDIA

Excellent Outcomes After First-Line Ablation in Post-MI Patients With Tolerated VT and LVEF >35%

Robert Rademaker, MD,[a,b] Marta de Riva, MD, PhD,[a,b] Sebastiaan R.D. Piers, MD, PhD,[a,b] Adrianus P. Wijnmaalen, MD, PhD,[a,b] Katja Zeppenfeld, MD, PhD[a,b]

ABSTRACT

BACKGROUND Post-myocardial infarction (MI) patients with ventricular tachycardia (VT) are considered at risk for VT recurrence and sudden cardiac death (SCD). Recent guidelines indicate that in selected patients catheter ablation should be considered instead of an implantable cardioverter-defibrillator (ICD).

OBJECTIVES This study aimed to analyze outcomes of patients referred for VT ablation according to left ventricular ejection fraction (LVEF), tolerance of VT, and acute ablation outcome.

METHODS Post-MI patients without prior ICD undergoing VT ablation at a single center between 2009 and 2022 were included. Patients who presented with tolerated VT and who had an LVEF >35% were offered catheter ablation as first-line therapy. ICD implantation was offered to all patients but was subject to shared decision according to clinical presentation, LVEF, and ablation outcome.

RESULTS Eighty-six patients (mean age 69 ± 9 years, 84% male, mean LVEF 41 ± 9%) underwent VT ablation. In 66 patients, LVEF was >35%, of whom 51 had tolerated VT. Of these 51 patients, 37 (73%) were rendered noninducible. In 5 of 37 noninducible and in 11 of 14 inducible patients, an ICD was implanted. During a median follow-up of 40 months (Q1-Q3: 24-70 months), 10 of 86 patients had VT recurrence. The overall mortality was 27%, and 1 patient with ICD died suddenly. Among the 37 patients (none on antiarrhythmic drugs) with LVEF >35%, tolerated VT, and noninducibility, no SCD or VT recurrence occurred. Among the 14 patients with LVEF >35%, tolerated VT, and inducibility after ablation, no SCD occurred, but VT recurred in 29%.

CONCLUSIONS Post-MI patients with LVEF >35%, tolerated VT, and noninducibility after ablation have an excellent prognosis. Deferring ICD implantation seems to be safe in these patients. (JACC Clin Electrophysiol. 2024;10:2303-2311)

Patients with sustained monomorphic ventricular tachycardia (SMVT) after myocardial infarction (MI) are at risk for ventricular tachycardia (VT) recurrence and arrhythmia-related sudden cardiac death (SCD).[1,2] In patients who present with hemodynamically tolerated SMVT, implantable cardioverter-defibrillators (ICDs) have been recommended for over 20 years for the prevention

From the [a]Department of Cardiology, Leiden University Medical Center, Leiden, the Netherlands; and the [b]Willem Einthoven Center of Arrhythmia Research and Management Leiden University Medical Center, Leiden, the Netherlands, and Aarhus, Denmark.

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ABBREVIATIONS AND ACRONYMS

AAD = antiarrhythmic drug

CL = cycle length

ICD = implantable cardioverter-defibrillator

LV = left ventricular

LVEF = left ventricular ejection fraction

MI = myocardial infarction

PCI = percutaneous coronary intervention

PES = programmed electrical stimulation

RV = right ventricular

SCD = sudden cardiac death

SMVT = sustained monomorphic ventricular tachycardia

VRP = ventricular refractory period

VT = ventricular tachycardia

VTCL = ventricular tachycardia cycle length

of SCD, regardless of the left ventricular ejection fraction (LVEF).[1] However, patients with tolerated SMVT and LVEF >35% have never been included in secondary prevention trials.[2,3] Modern strategies of early and complete revascularization including primary percutaneous coronary interventions (PCIs) and recent advances in heart failure treatment are likely to decrease the risk of SCD in contemporary post-MI cohorts.[4,5] ICDs do not prevent VT recurrence, and additional treatment is therefore required for patients with recurrent VT. Catheter ablation has evolved as a cornerstone in the treatment of post-MI VT.[1,6,7] Two observational studies have reported that in patients with tolerated VT and preserved or mildly reduced LVEF, catheter ablation without subsequent ICD implantation after successful ablation was safe, with few VT recurrence and no or rare sudden death.[8,9] In patients with hemodynamically tolerated VT and LVEF >35%, the risk of sudden death seems to be sufficiently low that an ICD may not be beneficial. Treatment of VT in these patients may be dissociated from SCD prevention.

Since 2009, catheter ablation has been offered in our center to all post-MI patients with LVEF >35% without prior ICD implantation, who present with hemodynamically tolerated SMVT, followed by shared decision making to refrain from ICD implantation after a successful ablation.

The aim of this study was to analyze the long-term outcome of patients treated according to this strategy.

METHODS

PATIENT COHORT. Since February 2009, consecutive post-MI patients without previous ICD implantation undergoing VT ablation at Leiden University Medical Center were prospectively included in a registry. All patients were treated according to our standard institutional clinical protocol. In brief, catheter ablation as first-line therapy is offered to all patients presenting with hemodynamically tolerated VT who have an LVEF >35%, with the option of not implanting an ICD for those with a successful procedure. Discharging without ICD implantation is based on shared decision making following a careful discussion of the available evidence (**Central Illustration**; Supplemental Figure 1). For patients presenting with nontolerated VT who have an LVEF >35% and patients who have an LVEF ≤35%, catheter ablation before or soon after ICD implantation is offered if long-term antiarrhythmic drug (AAD) treatment is not desired (**Figure 1**). In the period January 2017 to January 2022, the number of all post-MI patients receiving ICDs for secondary prevention (aborted SCD, VT) and the number of post-MI patients who underwent VT ablation without previous ICD implantation during the same period were determined.

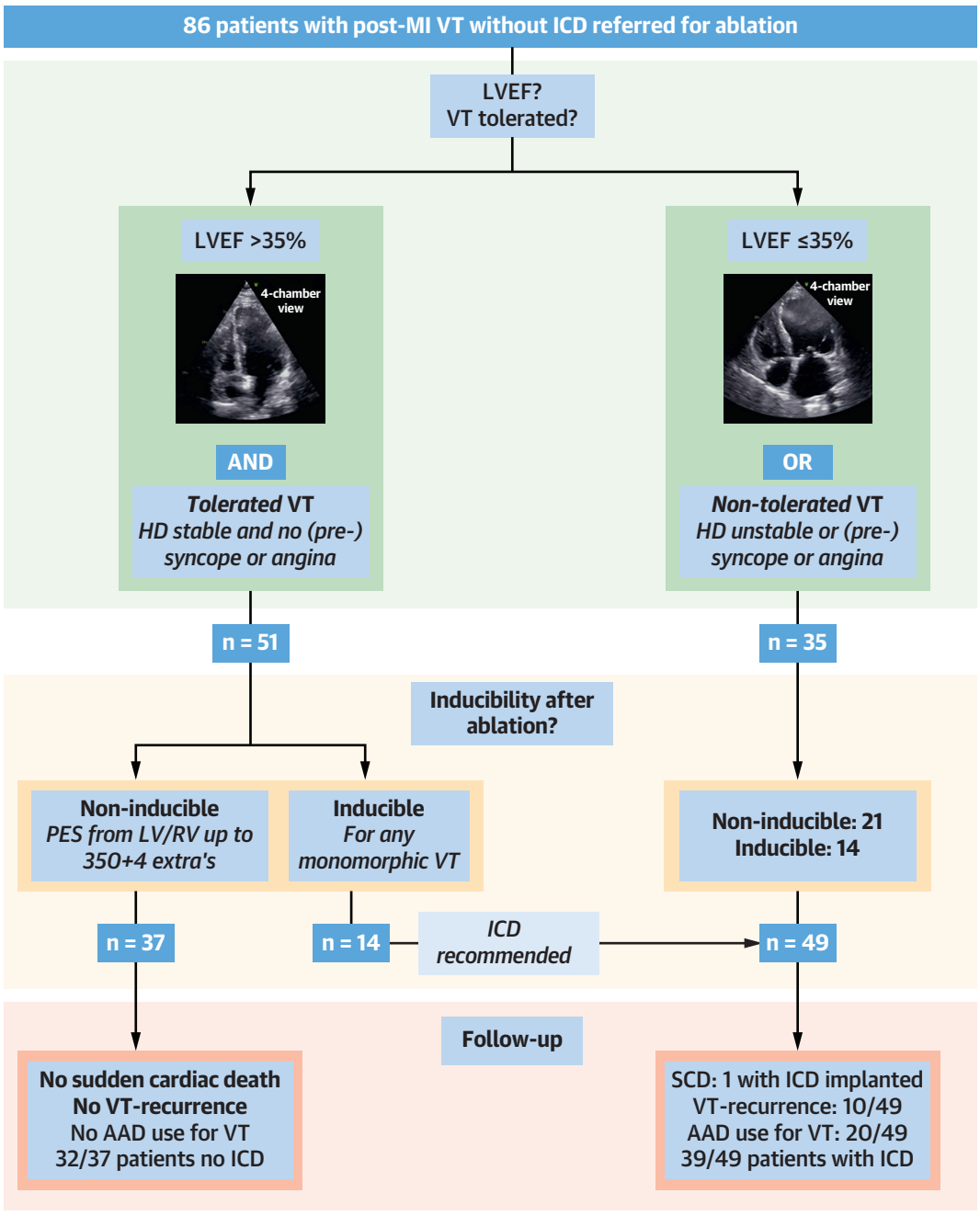
The Institutional Review Board approved this retrospective analysis and waived the need for patient informed consent for the study.

PREPROCEDURAL EVALUATION. All patients underwent clinical evaluation prior to the procedure including a medical history and routine laboratory testing. Medical records were reviewed for ischemic events, acute reperfusion therapy, prior revascularization by PCI or coronary artery bypass grafting, treatment for heart failure, and AADs. The potential for ischemia was assessed by coronary angiogram or coronary computed tomography, and significant stenosis was treated if deemed appropriate, prior to ablation. All electrocardiograms of VT(s) were collected. A VT was categorized as hemodynamically not tolerated when acute electrical cardioversion was needed because of hemodynamic instability, or when the patient presented with syncope, presyncope, or other severe VT-related symptoms, including angina and dyspnea. VTs not fulfilling any of these criteria were considered hemodynamically tolerated VT. An echocardiogram was performed to exclude (left ventricular [LV]) thrombus and to assess cardiac function. LV end-diastolic and end-systolic volumes were obtained from the apical 2- and 4-chamber views, and LVEF was calculated according to the biplane Simpson's method. Contrast was used when deemed necessary.

ABLATION PROCEDURE. Procedures were performed under conscious sedation, deep sedation, or general anesthesia when appropriate. All AADs, except for amiodarone, were discontinued for 5 half-lives. At the beginning of the procedure, programmed electrical stimulation (PES) was performed to induce VT. The PES protocol consisted of 4 drive cycle lengths (CLs) (600, 500, 400, 350 ms) with up to 4 extrastimuli down to 200 ms or ventricular refractory period (VRP) from 2 right ventricular (RV) and ≥1 LV sites.[6,10-12] Induced VTs were regarded clinical if the 12-lead electrocardiogram matched that of a spontaneous documented VT with a similar ventricular tachycardia cycle length (VTCL) (Δ <30 ms).

Endocardial electroanatomic mapping of the LV was performed in all patients using a retrograde aortic and/or transseptal approach during sinus rhythm or

CENTRAL ILLUSTRATION **Management of Consecutive Post-MI VT Ablation Patients Without ICD**



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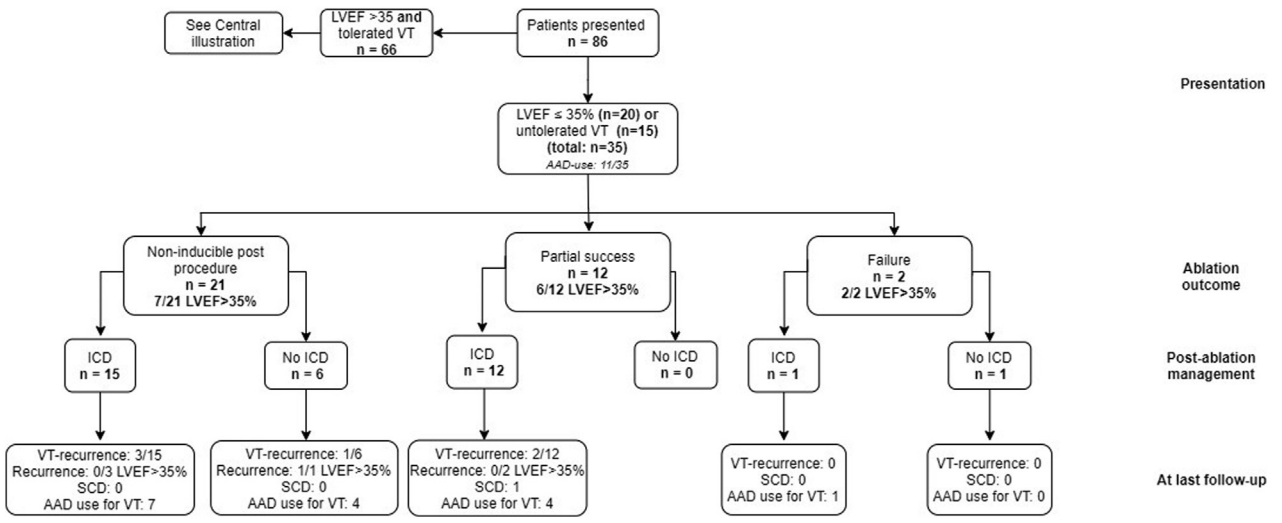
AAD = antiarrhythmic drug; HD = hemodynamically; ICD = implantable cardioverter-defibrillator; LV = left ventricle; LVEF = left ventricular ejection fraction; MI = myocardial infarction; PES = programmed electrical stimulation; RV = right ventricle; SCD = sudden cardiac death; VT = ventricular tachycardia.

RV pacing with a 3.5-mm irrigated-tip catheter (NAVISTAR THERMOCOOL or THERMOCOOL SMARTTOUCH SF, or QDot; Biosense Webster) and the CARTO3 system (Biosense Webster).

In short, patients underwent substrate ablation based on elimination of late potentials and fragmented electrograms. Pace mapping was used to identify VT-related sites. Starting in October 2013, a

FIGURE 1 Management of Patients With a Class I Indication for ICD According to the Guideline



AAD = antiarrhythmic drug; ICD = implantable cardioverter-defibrillator; LVEF = left ventricular ejection fraction; SCD = sudden cardiac death; VT = ventricular tachycardia.

systematic pacing protocol (evoked delayed potential mapping) with extrastimuli and the subsequent response of the local electrogram was used for substrate identification.[6] If any SMVT remained inducible, additional mapping and ablation was performed until no further substrate could be identified. Fast VTs with a CL close to VRP (VRP +30 ms) were considered clinically not relevant and not targeted by ablation.[13] For details on the ablation procedure, see the Supplemental Appendix.

ACUTE ABLATION OUTCOME. After ablation, patients were classified as: 1) noninducible if they were no longer inducible for any SMVT; 2) inducible for clinical VT if they remained inducible for the clinically documented VT; and 3) inducible for nonclinical VT(s) if they remained inducible for nonclinical SMVTs only. Patients who were not inducible at baseline (before ablation) and subsequently remained noninducible after the procedure were categorized as noninducible. A procedure was considered successful if the patient was noninducible for any SMVT and if the VT substrate, as defined by mapping, was eliminated by ablation (see Supplemental Appendix).

POSTPROCEDURAL MANAGEMENT. After ablation, in patients with LVEF ≤35% and in those presenting with hemodynamically nontolerated VTs, ICD implantation was recommended during the same hospital admission. In patients with LVEF >35% and tolerated VT, who remained inducible for any VT after ablation, ICD implantation was also recommended. To patients with LVEF >35% and tolerated VT, who were rendered uninducible for any VT, ICD implantation was offered during the same hospital admission but was subject to shared decision. LVEF derived from echocardiography was used to assign patients to groups, as echocardiography was used in prior primary prevention ICD implantation studies.[2,3]

FOLLOW-UP. Patients were followed 3 and 6 months after the procedure and every 6 months thereafter. Follow-up visits included a medical history focused on symptoms compatible with VT recurrence and ICD interrogation when appropriate. Patients discharged without ICD were instructed to immediately contact emergency services in case of symptoms consistent with recurrent VT including palpitations, (pre)syncope, angina, and acute dyspnea. Patients were followed for VT recurrence, AAD use at latest follow-up, all-cause mortality, and SCD. For patients not followed at our institution, the referring cardiologist, the general practitioner, and/or the patient were contacted for AAD use, VT recurrence, and if applicable, cause of death.

STATISTICAL ANALYSIS. Continuous variables are reported as mean ± SD or median (Q1-Q3) and compared with Student's *t* test or the Mann-Whitney *U* test, when appropriate. Categorical variables are expressed as number and percentage and compared with the chi-square or Fisher exact test. Survival

analysis was performed using Kaplan-Meier survival curves. All tests were 2 sided and a P value <0.05 was considered statistically significant. Statistical analyses were performed with SPSS version 27.0 (IBM).

RESULTS

PATIENTS. Between February 2009 and January 2022, 86 post-MI patients (84% men, age 69 ± 9 years, LVEF 41 ± 9%, 66 [77%] LVEF >35%) without prior ICD underwent VT ablation in our center. Most patients had a prior inferior wall infarction (60%) and 80% had undergone prior revascularization. The majority of patients underwent a coronary angiogram at admission (84%), with 35% of patients undergoing PCI at admission. All patients who were discharged without an ICD had undergone a coronary angiogram and, when necessary, PCI before discharge. The majority (n = 80) were referred for ablation after the first presentation with a sustained VT and 6 patients because of incessant VT. The median VTCL was 323 ms (Q1-Q3: 300-375 ms). VT was hemodynamically tolerated in 59 (69%) patients.

Baseline clinical characteristics are shown in Table 1.

TABLE 1 Patient Characteristics

	All (N = 86)	LVEF >35% (n = 66)	LVEF ≤35% (n = 20)	*P* Value
Age, y	69 ± 9	69 ± 9	70 ± 10.0	0.57
Male	72 (84)	58 (88)	14 (70)	0.06
Hypertension	49 (57)	40 (61)	9 (45)	0.83
Diabetes mellitus	20 (23)	15 (23)	5 (25)	0.22
Hypercholesterolemia	40 (47)	32 (49)	8 (40)	0.51
Prior stroke/TIA	7 (8)	7 (11)	0 (0)	0.13
Atrial fibrillation	24 (28)	18 (27)	6 (30)	0.81
Time since MI, y	15 (7-23)	16 (7-23)	14 (2-23)	0.37
Creatinine	101 ± 61	102 ± 66	98 ± 37	0.42
LVEF, %	41 ± 9	45 ± 6	29 ± 5	<0.001
Prior PCI	56 (65)	44 (67)	12 (60)	0.58
Prior CABG	37 (43)	27 (41)	10 (50)	0.47
Any revascularization (PCI/CABG)	69 (80)	54 (81)	15 (75)	0.50
CAG at admission	72 (84)	55 (83)	17 (85)	0.86
PCI at admission	30 (35)	23 (35)	7 (35)	0.98
Prior pacemaker	5 (6)	3 (5)	2 (10)	0.36
Scar location				
Anterior	18 (21)	9 (13)	9 (45)	0.003
Apical	6 (7)	5 (8)	1 (5)	0.69
Lateral	10 (12)	8 (12)	2 (10)	0.80
Inferior	52 (60)	44 (67)	8 (40)	0.03
Clinical presentation				
First presentation of VT	65 (76)	50 (76)	15 (75)	0.95
VT recurrence after AAD use	15 (17)	11 (17)	4 (20)	0.73
Incessant VT	6 (7)	5 (8)	1 (5)	0.69
Clinical VT cycle length, ms	323 (300-375)	316 (289-369)	347 (315-398)	0.02
Hemodynamically tolerated VT	59 (69)	51 (77)	8 (40)	
VT cycle length of tolerated VTs, ms	325 (300-371)	320 (290-366)	348 (334-416)	0.03
VT cycle length of nontolerated VTs, ms	314 (298-380)	303 (269-376)	342 (303-395)	0.16
Medications at admission				
Beta-blocker	67 (78)	51 (77)	16 (80)	0.79
ACE inhibitor/ARB	60 (70)	47 (71)	13 (65)	0.60
Aldosterone antagonist	17 (20)	11 (17)	6 (30)	0.19
Statins	73 (85)	58 (88)	15 (75)	0.16
Diuretics	21 (24)	11 (17)	10 (50)	0.002
Amiodarone	6 (7)	5 (8)	1 (5)	0.69
Sotalol	16 (19)	13 (20)	3 (15)	0.64
Class 1	2 (2)	1 (2)	1 (5)	0.37

Values are mean ± SD, n (%), or median (Q1-Q3).

AAD = antiarrhythmic drug; ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker; CABG = coronary artery bypass grafting; CAG = coronary angiogram; ICD = implantable cardioverter-defibrillator; LVEF = left ventricular ejection fraction; MI = myocardial infarction; PCI = percutaneous coronary intervention; TIA = transient ischemic attack; VT = ventricular tachycardia.

ABLATION PROCEDURE AND ACUTE OUTCOME. Before ablation, 76 (88%) patients were inducible for a median of 2 (Q1-Q3: 1-3) distinct VTs (median induced VTCL 322 ms [Q1-Q3: 280-379 ms]). In all but 2 (n = 74), the clinically documented VT was induced. Six (12%) of 51 patients with LVEF >35% and hemodynamically tolerated VT were noninducible before and during the procedure. Six (7%) patients were on amiodarone. Substrate modification with elimination of areas of slow conduction was successfully performed in all patients. After the last radiofrequency application, PES was performed in all but 1 patient, in whom patient discomfort led to early procedural termination. This patient was classified as having procedural failure.

Overall, 58 (67%) patients were noninducible for any SMVT at the end of the procedure. In 26 (30%), nonclinical VTs remained inducible (median VTCL 240 ms [Q1-Q3: 220-272 ms], n = 20 of 26 VTCL ≤250 ms) and 2 patients had procedural failure.

POSTABLATION MANAGEMENT. For postablation management, see the Central Illustration, Figure 1, and Supplemental Figure 1.

Patients with LVEF >35% and tolerated VT. Fifty-one (59%) patients had an LVEF >35% and presented with tolerated VT. Of those, 37 (73%) of 51 patients were noninducible after ablation. Following shared decision making, 32 of 37 patients were discharged without an ICD, and in 5 an ICD was implanted because of patient preference. In the 14 (27%) patients who remained inducible for nonclinical VTs (median VTCL 238 ms [Q1-Q3: 203-288 ms], 10 of 14 for fast VTs with VTCL ≤250 ms only) ICD implantation was recommended but refused by 3 patients.

TABLE 2 Outcome Data

	All (N = 86)	LVEF > 35% and HD Tolerated VT (n = 51)	LVEF ≤35% or HD Nontolerated VT (n = 35)	*P* Value
Follow-up, mo	40 (24-70)	41 (26-69)	38 (21-85)	0.98
AAD at discharge				
All	35 (41)	14 (28)	21 (60)	0.003
Amiodarone	18 (21)	5 (10)	13 (37)	0.002
Sotalol	16 (19)	9 (18)	7 (20)	0.78
Class 1	1 (1)	0 (0)	1 (3)	0.23
AAD at last follow-up				
All	28 (33)	10 (20)	18 (51)	0.002
Amiodarone	14 (16)	3 (6)	11 (31)	0.002
Sotalol	13 (15)	7 (14)	6 (17)	0.64
Class 1	1 (1)	0 (0)	1 (3)	0.23

Values are median (Q1-Q3) or n (%).
HD = hemodynamically; other abbreviations as in Table 1.

Patients with Class I recommendation for ICD implantation according to 2022 European Society of Cardiology guidelines. Twenty (23%) patients had an LVEF ≤35% and 15 (18%) patients had an LVEF >35% but presented with nontolerated VTs. Of these 35 patients with a current Class I indication for ICD implantation, 21 (60%) patients were rendered noninducible after ablation and 12 (34%) remained inducible for nonclinical VTs (median remaining VTCL 235 ms [Q1-Q3: 220-250], 10 of 12 VTCL ≤250 ms), and in 2 (6%) the clinical VT could not be abolished. In all 35 patients, ICD implantation was recommended, but 7 (20%) patients refused implantation. In the period from January 2017 to the end of the study period (January 2022), a total of 342 post-MI patients received an ICD for secondary prevention of SCD. During the same period, 31 study patients underwent VT ablation, of which 16 were discharged without ICD.

LONG-TERM OUTCOMES. During a median follow-up of 40 months (Q1-Q3: 24-70 months), 10 (12%) of 86 patients had VT recurrence and 23 (27%) of 86 patients died (Supplemental Table 1).

Patients with LVEF >35% and tolerated VT. Of the 51 patients, 37 were noninducible after ablation and none of those had VT recurrence or experienced SCD during a median follow-up of 39 months (Q1-Q3: 25-71 months). At the last follow-up, 6 (16%) of the 37 patients were using AADs, all for the treatment of atrial arrhythmias (Table 2).

Of the 14 patients who remained inducible for nonclinical VTs, 4 (29%) had VT recurrence after a median follow-up of 45 months (Q1-Q3: 34-66 months). The median CL of recurrent VT was 303 ms (Q1-Q3: 200-374 ms). Two patients presented with a VTCL similar to the previous clinical VTCL (ΔVTCL ≤30 ms) and 2 with faster VTs (VTCL 235 ms and 190 ms, respectively). All 4 patients had been discharged with ICDs. At last follow-up, 4 (29%) of 14 patients who remained inducible for nonclinical VTs were using AADs to prevent VT recurrence. The **Central Illustration** provides an overview and Supplemental Table 2 and **Figure 1** the details.

Eight of the 51 (16%) patients with LVEF >35% and tolerated VT died (median survival 130 months [95% CI: 108-151 months]), 4 due to heart failure and 4 due to a noncardiac cause. There were no SCDs in this group.

PATIENTS WITH LVEF ≤35% OR LVEF >35% AND NONTOLERATED VTs. In total, 6 (17%) of 35 patients had VT recurrence a median of 14 months (Q1-Q3: 2-33 months) after ablation with a median VTCL of 369 ms (Q1-Q3: 288-450 ms). All patients with VT recurrence had an ICD implanted, except 1 patient who had refused ICD implantation and presented with a slow, hemodynamically tolerated VT (VTCL 400 ms).

At last follow-up, 16 (46%) of 35 patients were using AAD to prevent VT recurrence (**Figure 1**; Supplemental Table 2). Fifteen (43%) of 35 patients died (median survival 91 months [95% CI: 40-142 months), 7 due to heart failure and 7 from noncardiac causes. There was 1 SCD in a patient with an ICD (**Table 2**) (see Supplemental Tables 1 and 2).

DISCUSSION

To the best of our knowledge, this is the largest study, and the first conducted in contemporary post-MI patients, evaluating VT ablation as first-line treatment in patients who present with hemodynamically tolerated VT and who had an LVEF >35% with the option of refraining from backup ICD when ablation was acutely successful. The main findings can be summarized as follows. First, contemporary post-MI patients with an LVEF >35% who presented with hemodynamically tolerated VT, who were noninducible for any VT after ablation, had an excellent long-term outcome. None had VT recurrence or experienced SCD during a median follow-up of 3 years, despite only 14% receiving an ICD. On the contrary, 29% of patients with LVEF >35% and tolerated VTs who remained inducible for nonclinical and typically fast VTs recurred with a VT of similar or shorter VTCL to the initial presentation. Second, in patients who presented with LVEF ≤35% and/or hemodynamically nontolerated VTs who were noninducible after ablation, VT recurred in 19%.

These data suggest that in contemporary post-MI patients with mildly reduced cardiac function,

stable VT that can be successfully ablated is not a marker for a malignant arrhythmia substrate that necessitates ICD implantation for prevention of SCD. In contrast, patients with poor cardiac function, with nontolerated VT, or who remain inducible for VT, even when that VT is considered nonclinical, have a more serious electrophysiological substrate that is not reliably controllable by ablation and should receive ICDs according to current guidelines.

ICD FOR SECONDARY PREVENTION OF ARRHYTHMIC DEATH. Three pivotal trials conducted more than 20 years ago have shown that ICDs reduce arrhythmic death in post-MI patients who present with resuscitated cardiac arrest due to ventricular arrhythmia,[2] syncopal VT or ventricular fibrillation, or VT and symptoms of hemodynamic compromise (presyncope, congestive heart failure, angina) and an LVEF ≤40%,[3] or an LVEF ≤35%.[2,3,14,15] Of note, no survival benefit was reported for patients with an LVEF >35% in a meta-analysis of these trials.[16] Data on a potential benefit of ICD implantation in patients who have an LVEF >35% and present with well-tolerated VT without symptoms of hemodynamic compromise are scarce. Limited data from registries or observational studies come from patients followed in the 1990s, prior to current management of coronary artery disease, modern heart failure management, and beta-blocker use, and with a lack of information on follow-up therapy.[17,18] Despite the lack of evidence for survival benefit, ICD implantation has been recommended by previous guidelines also for these patients. ICDs can reliably terminate VT; however, ICD shocks are associated with anxiety and depression, and additional treatment to prevent VT recurrence is often required.[19] In addition, ICD-related complications, including ICD-related mortality, costs, and ongoing surveillance of the device once implanted, need to be considered.[20] These considerations are particularly relevant for patients who do not receive a survival benefit from the device, and in whom alternative treatment modalities for VT are available.

CATHETER ABLATION FOR VT. Radiofrequency catheter ablation has become an important treatment option to prevent VT recurrence in post-MI patients. Modern approaches targeting the functional VT substrate achieve a high procedural success and excellent VT-free survival, in particular in post-MI patients with mildly reduced LV function who were rendered noninducible after ablation.[6,21,22] Even if a well-tolerated VT recurs, this is rarely a life-threatening event in patients with well-managed ischemic disease,[8,9,23] although it is often unjustly considered as a surrogate for arrhythmic death in patients with ICDs.[18]

CATHETER ABLATION AS FIRST-LINE TREATMENT. There are only limited outcomes data of patients who underwent successful VT ablation and were discharged without ICD backup. One multicenter study included patients with various etiologies, 55% with ischemic heart disease and an LVEF >30%, who presented with VT and were discharged without ICD after ablation.[9] Ablation strategies, endpoints, and the decision to not implant an ICD were not uniform and left to the discretion of the center. Of note, of the 166 patients, 44% had symptoms of hemodynamic compromise at the time of presentation. After ablation 13% remained inducible and in 4% no PES was performed. Despite absence of an ICD, after successful ablation mortality and SCD rates were low. However, 4 patients (2.4% of the study cohort) died suddenly, 3 of whom had a prior MI, all of whom had presented with symptoms of hemodynamic compromise (near syncope and angina), despite mid-range or preserved LVEF and VT rates ranging between 135 and 170 beats/min. Systematic testing for residual ischemia and treatment before discharge was not reported. Significant residual coronary artery disease can explain severe VT symptoms despite slow VT rates in patients with preserved LVEF, and may explain SCD.

Two prior retrospective, single-center studies have specifically reported on VT recurrence and survival after catheter ablation in post-MI patients without routine ICD implantation.[8,23] In one series, 25 patients who were noninducible for VT slower than 270 beats/min after the last ablation and at a repeat PES 2 to 3 months later from 2 RV sites were followed without an ICD, regardless of initial VT symptoms. The remaining 19 underwent ICD implantation. During a median follow-up of 4.5 years, 31.1% died. ICDs did not impact survival. Two patients in the ICD group died as a result of intractable VT, and 1 patient in the group without ICD died suddenly.[23] In the second study, 31 post-MI patients with hemodynamically tolerated VT and an LVEF ≥40% underwent catheter ablation.[8] Of the 18 patients who were rendered noninducible for any MSVT and were originally left without ICD, only 2 (11%) had VT recurrence of hemodynamically tolerated VT, followed by ICD implantation in 1. During a mean follow-up of 3.8 years, 42% died. Of note, no sudden death occurred in patients without ICDs.

Similar to these reports, we aimed to evaluate catheter ablation as first-line treatment for tolerated VT in post-MI patients but with important differences in patient selection, definition of tolerated VT, mapping, and evaluation of ablation outcome.

First, VT ablation as first line treatment was specifically offered to patients with an LVEF >35% and VT without any symptoms of hemodynamic compromise, as these patients have not been shown to have a mortality benefit from an ICD. Of note, and in contrast to prior studies, patients with severe VT symptoms at presentation were considered candidates for ICDs regardless of ablation outcome. In this subgroup, 1 of 7 patients experienced VT recurrence despite ablation success. Second, our cohort was larger than previous series and treated according to currently accepted protocols. Ablation not only targeted induced VT[23] and late potentials,[8] but also systematically targeted the functional substrate identified as sites with conduction delay following pacing maneuvers. With this approach, 73% of our patients with stable VT and LVEF >35% were rendered noninducible, despite aggressive programmed stimulation from multiple RV and LV sites with 3 to 4 different basic paced CLs as short as 350 ms, and 4 extrastimuli. Third, patients were systematically tested and treated for residual ischemia, which may have contributed to the overall lower annual mortality rate of 5%, compared with 11% in a prior report.[8] Following this approach, none of the noninducible patients experienced VT recurrence or died suddenly.

PES RESULTS AND OUTCOME. As in prior studies, partial success of ablation defined as inducible nonclinical fast VTs (median VTCL 238 ms [Q1-Q3: 203-288 ms]) was associated with VT recurrence. Of interest, procedural success with no inducible VT was achieved in only 7 (47%) of 15 patients with an ejection fraction >35% who presented with hemodynamically nontolerated VT (median VTCL 300 ms [Q1-Q3: 269-376 ms]). Although numbers are small, it is interesting to speculate that fast VTs in patients with mildly reduced LV function, either occurring spontaneously or remaining inducible after ablation of a well-tolerated VT, may indicate a substrate more challenging to delineate and ablate with current substrate-based approaches.

In the PRESERVE-EF (Arrhythmic risk stratification in post-myocardial infarction patients with preserved ejection fraction) study, post-MI patients with LVEF ≥40%, at least 1 noninvasive risk factor, and without any evidence of ischemia underwent PES for risk stratification followed by ICD implantation in case of inducibility. None of the patients with a negative PES had a major arrhythmic event, but 6 of 35 inducible patients had appropriate ICD therapy. Of note, all were inducible for fast monomorphic VT with a median VTCL of 244 ms (Q1-Q3: 216-247 ms). These data support the good negative predictive value of a negative PES in post-MI patients with mildly reduced LVEF and the association of inducible fast VT with spontaneous VT. In our cohort, 2 of 4 patients with mildly reduced function and tolerated VT, who remained inducible for fast VT (CL <250 ms), also recurred with a fast VT. In a previous study from our group, including a mixed cohort of patients with ischemic cardiomyopathy and nonischemic cardiomyopathy, patients with inducible rapid VTs with a VTCL close to refractory period after ablation rarely had recurrence of VT.[13] Although the number of patients is small, the findings in the present study raise concern that induction of fast VT in patients with mildly reduced LVEF after MI cannot be considered an innocent finding.

STUDY LIMITATIONS. Important limitations are the small study size and the observational study design. However, patients were treated according to a standardized institutional protocol and followed prospectively. Patients were treated in a high-volume single center, which may limit the generalization of the results. We did not perform PES 2 to 3 months after ablation. However, as no VT recurred in patients with LVEF >35%, tolerated VT, and noninducibility using an extensive induction protocol, additional PES would not have impacted the outcome.

CONCLUSIONS

Contemporary post-MI patients with stable coronary disease, LVEF >35% who present with tolerated VT, without symptoms of hemodynamic compromise, and who are noninducible after functional substrate ablation have an excellent prognosis. Refraining from ICD implantation seems to be safe in these selected patients.

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ADDRESS FOR CORRESPONDENCE: Dr Katja Zeppenfeld, Leiden University Medical Center, Department of Cardiology (C-05-P), P.O. Box 9600, 2300 RC Leiden, the Netherlands. E-mail: k.zeppenfeld@lumc.nl.

PERSPECTIVES

COMPETENCY IN PATIENT CARE AND PROCEDURAL SKILLS: We hope this paper advances the medical knowledge domain as set out in the Accreditation Council for Graduate Medical Education, with results suggesting that in post-MI patients with tolerated VTs and preserved ejection fraction, arrhythmic prognosis is excellent after successful functional substrate ablation.

TRANSLATIONAL OUTLOOK: The results suggest that in post-MI patients with tolerated VTs and preserved ejection fraction, arrhythmic prognosis is excellent after successful functional substrate ablation. This study provides important information on safety for electrophysiologists, and (large) randomized controlled trials are needed to further evaluate this approach.

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KEY WORDS implantable cardioverter-defibrillator, ischemic cardiomyopathy, radiofrequency catheter ablation, sudden cardiac death, ventricular tachycardia

APPENDIX For an expanded Methods and References sections and supplemental tables and figures, please see the online version of this paper.