Outcomes in Catheter Ablation of Ventricular Tachycardia in Dilated Nonischemic Cardiomyopathy Compared With Ischemic Cardiomyopathy

Results From the Prospective Heart Centre of Leipzig VT (HELP-VT) Study

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**Background**—Data on the outcomes of ventricular tachycardia (VT) ablation in nonischemic dilated cardiomyopathy (NIDCM) are insufficient. The Heart Center of Leipzig VT (HELP-VT) study was conducted prospectively to compare outcomes after radiofrequency catheter ablation of VT in patients with NIDCM compared with ischemic cardiomyopathy (ICM).

**Methods and Results**—Two hundred twenty-seven patients, 63 with NIDCM and 164 with ICM, presenting with sustained VT were ablated with radiofrequency catheter ablation. Noninducibility of any clinical and nonclinical VT was achieved in 66.7% of NIDCM and in 77.4% of ICM patients. Ablation of the clinical VT only was achieved in 18.3% of ICM and in 22.2% of NIDCM patients. There was no statistically significant difference in short-term outcomes between the 2 groups. At the 1-year follow-up, VT-free survival in NIDCM was 40.5% compared with 57% in ICM. In univariate analysis, the hazard ratio for VT recurrence was significantly higher for NIDCM (1.62; 95% confidence interval, 1.12–2.34; \( P = 0.01 \)). In both the ICM and NIDCM subgroups, procedure failure and incomplete procedural success were independent predictors of VT recurrence.

**Conclusions**—Although the short-term success rates after VT ablation in NIDCM and ICM patients were similar, the long-term outcomes in NIDCM patients were significantly worse. Complete VT noninducibility at the end of the ablation is associated with beneficial long-term outcome in NIDCM. Pursuing complete elimination of all inducible VTs is desirable and may improve the long-term success in NIDCM. (Circulation. 2014;129:728-736.)

**Key Words:** cardiomyopathy, dilated ✓ catheter ablation ✓ outcome assessment (health care)

Evidence supporting the effectiveness and safety of radiofrequency catheter ablation of ventricular tachycardia (VT) is based primarily on data from 2 randomized, prospective, multicenter studies and some single-center and nonrandomized studies in patients with coronary artery disease.1–6 The reported variability in ablation outcomes in these studies reflects the differences in the ablation approach, the definitions of short- and long-term success, and the use of different antiarrhythmic drugs (AADs) after ablation.1,5–7 Studies addressing the outcomes in nonischemic dilated cardiomyopathy (NIDCM) patients are fewer, include smaller groups of patients, and have reported worse outcomes.8–12 A more recent multicenter trial in epicardial VT ablation suggested comparable outcomes in ischemic cardiomyopathy (ICM) and NIDCM, with a reported VT recurrence in 39.3% in NIDCM versus 34.7% in ICM.13

Clinical Perspective on p 736

There is also great uncertainty about the determinants and predictors of short- and long-term success of VT ablation.

Studies in VT ablation in ICM patients have shown rather contradictory results, with some of the trials proving the importance of acute VT noninducibility as an independent predictor of long-term VT-free survival and others failing to demonstrate such a dependency.2–7 Data on NIDCM are even more scarce. In a recent study in patients with NIDCM VT, noninducibility failed to predict long-term success even after epicardial ablation.12

The Heart Center of Leipzig VT (HELP-VT) study was conducted prospectively to compare the outcomes after radiofrequency catheter ablation of VT in NIDCM and ICM. Furthermore, we sought to determine the predictors for the short- and long-term success rates in NIDCM.

**Methods**

**Definitions of ICM and NIDCM**

The distinction between ICM and NIDCM was based primarily on the presence of relevant coronary artery disease confirmed with a coronary angiography. NIDCM was identified as an absence of relevant coronary artery disease and defined according to the criteria of the

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Outcomes After RFCA of VT in NIDCM Versus ICM

European Society of Cardiology Working Group for Myocardial and Pericardial Diseases. Patients with acquired DCM resulting from toxic agents, nutritional causes, or systemic and endocrine diseases were excluded from the study. The rational for this exclusion was that secondary myocardial damage resulting from toxic, nutritional, or endocrine causes could be reversible after elimination of the primary cause. In addition, some toxic substances could induce VTs with a nonreentrant mechanism (digitals, daunorubicin, etc.).

Patient Population

On the basis of the above-mentioned definitions, 227 patients with NIDCM and ICM (197 male; mean age, 65.1±11.7 years; mean ejection fraction, 32.7±11.2%; NIDCM in 63 patients, 28.1%) presenting with recurrent sustained VT were enrolled in the study. Baseline and procedure data were derived from HELP-VT. All patients were ablated with radiofrequency energy in the period between January 2008 and December 2011. In cases with >1 VT ablation, the first procedure was taken as the index ablation. Cases with bundle-branch reentry VT were also excluded from the study because of the different electrophysiological mechanisms and ablation approaches. In the overall population, 208 patients (91.6%) had an implantable cardioverter-defibrillator (ICD) or cardiac resynchronization therapy defibrillator; 101 patients (44.5%) presented with electric storm, defined as >3 VTs requiring ICD therapy (antitachycardia pacing or shocks) or external defibrillation in 24 hours.

At admission, 156 patients (95.1%) with ICM were on β-blocker therapy compared with 57 patients (90.5%) with NIDCM (P=0.221). At admission, 21 patients (33.3%) with NIDCM were on amiodarone therapy compared with 64 patients (39%) with ICM (P=0.448). Patient characteristics for NIDCM and ICM are summarized in Table 1.

Endocardial Versus Epicardial Access

All patients signed informed consent before the ablation procedure and were prepared according to the clinical routine of our department. Whenever possible, the antiarrhythmic medication was withheld for a period of 5 half-lives before the ablation. Because a significant proportion of cases were ablated in emergency settings, the withdrawal of the AAD, mainly amiodarone, before the procedure was not possible. The procedure was performed under deep sedation with direct arterial blood pressure and oxygen saturation monitoring. The primary approach in all cases was endocardial ablation. In most patients, the left ventricular cavity was reached via a transseptal puncture; a retrograde transaortic access was used only occasionally. The technique for transseptal puncture was performed with a steerable introducer (Agilis, St. Jude Medical, St. Paul, MN). The decision for epicardial approach was based on the VT QRS morphology in a 12-lead ECG, failure of a prior endocardial attempt to abolish the VT, or no dense confluent scar revealed by endocardial voltage mapping. The technique for the subxyphoid puncture is described in detail elsewhere. In cases when endocardial mapping and epicardial mapping appear to be necessary, the subxyphoid puncture was performed first to avoid inadvertent bleeding complications. After entering the left ventricular cavities, heparin was administered to maintain an activation clothing time of >300 seconds.

Programmed Electric Stimulation

Data were recorded with a multichannel recording system (Prucka CardioLab, GE Healthcare). If not ongoing, an attempt to induce either clinical or nonclinical monomorphic VT was made. We used programmed electric stimulation from the right ventricular apex and outflow tract with 4 different drive cycle lengths (500, 430, 370, and 330 milliseconds) and introduction of up to 3 extrastimuli until a ventricular effective refractory period or a coupling interval of 200 milliseconds was reached. If not inducible, additional stimulation in the left ventricle was performed. The same induction protocol was used to reinduce the VT after ablation. Isoproterenol was not used in our stimulation protocol.

Electroanatomic Mapping and Catheter Ablation

Catheter mapping was performed in sinus rhythm with fluoroscopy and an electroanatomic 3-dimensional mapping system (Carto 3, Biosense Webster Inc; or EnSite, St. Jude Medical). We defined dense scar as areas with local bipolar electrogram peak-to-peak voltage <0.5 mV and healthy tissue as areas demonstrating local bipolar electrograms ≥1.5 mV. Additionally, we annotated all fragmented, late potentials and appropriate pacing sites on the map. In patients with hemodynamically stable VTs, activation and entrainment mapping was performed to locate possible exit sites and critical isthmuses. In hemodynamically unstable VTs, limited activation mapping and pace mapping were used to further guide the ablation. Given that the substrate in DCM frequently involves the epicardial layers, epicardial mapping and ablation were performed more frequently in NIDCM patients compared with ICM patients. Keeping in mind the effects of epicardial fat and coronary vasculature on epicardial signals, we defined abnormal epicardial electrograms as signals with durations of >80 milliseconds, demonstrating fractionation with ≥2 components, or demonstrating late potentials with an onset well after the QRS.

Radiofrequency energy was used for ablation with open irrigated-tip ablation catheters with power settings of up to 50 W and an irrigation rate up to 30 mL/min (Thermocoool, Biosense Webster Inc, Diamond

Table 1. Baseline Clinical Characteristics

<table>
<thead>
<tr>
<th></th>
<th>NIDCM (n=63)</th>
<th>ICM (n=164)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>59.2±13.47</td>
<td>67.4±10.09</td>
<td>0.0001</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>52 (82.5)</td>
<td>142 (88.4)</td>
<td>0.275</td>
</tr>
<tr>
<td>Atrial fibrillation/flutter, n (%)</td>
<td>30 (47.6)</td>
<td>83 (50.6)</td>
<td>0.767</td>
</tr>
<tr>
<td>ICD/CRT-D, n (%)</td>
<td>60 (95.2)</td>
<td>149 (90.9)</td>
<td>0.411</td>
</tr>
<tr>
<td>Electric storm, n (%)</td>
<td>34 (54)</td>
<td>67 (40.9)</td>
<td>0.1</td>
</tr>
<tr>
<td>β-Blocker at admission, n (%)</td>
<td>57 (90.5)</td>
<td>156 (95.1)</td>
<td>0.221</td>
</tr>
<tr>
<td>Amiodarone at admission, n (%)</td>
<td>21 (33.3)</td>
<td>64 (39)</td>
<td>0.448</td>
</tr>
<tr>
<td>Arterial hypertension, n (%)</td>
<td>30 (47.6)</td>
<td>135 (82.3)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>18 (26.8)</td>
<td>66 (40.2)</td>
<td>0.125</td>
</tr>
<tr>
<td>Heart failure, NYHA class &gt;II, n (%)</td>
<td>34 (55.7)</td>
<td>91 (63.2)</td>
<td>0.349</td>
</tr>
<tr>
<td>LVEF, %</td>
<td>33.7±11.09</td>
<td>32.3±11.26</td>
<td>0.414</td>
</tr>
</tbody>
</table>

Categorical data are presented as number and percentage; continuous data, as mean and standard deviation. A 2-sided value of P<0.05 indicates significance. ICD/CRT-D indicates implantable cardioverter-defibrillator/cardi resynchronization therapy defibrillator; ICM, ischemic cardiomyopathy; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; and NIDCM, nonischemic dilated cardiomyopathy.
Bar, CA) or 50 W and a flow rate of 15 mL/min (Thermocool SF, Biosense Webster Inc). In cases when the EnSite NavX system was used, we used an irrigated-tip Coolflex catheter with 50 W and an irrigation rate of 17 mL/min. In the epicardium, a lower irrigation rate of 4 mL/min was used to avoid fluid overload in the pericardial space.

**Study End Points**

Ablation end points were defined according to the latest guideline recommendations.\(^1^9\) Ablation of the clinical VT only was defined as partial short-term success. Clinical tachycardia was determined from the available 12-lead ECG or VT cycle length in the ICD memory. Far-field electrogram morphology was not routinely taken into consideration to distinguish the VT morphology. Other nonclinical monomorphic and hemodynamically stable VTs inducible during the procedure were also targeted for ablation. Complete elimination of any clinical and nonclinical stable monomorphic VT was defined as complete short-term success. Reinduction of clinical and nonclinical VTs despite ablation was defined as procedure failure. VT recurrence was defined as any episode of sustained VT occurring after the ablation procedure or requiring ICD therapy or detected in the monitor zone of the ICD or the ECG. Major procedure-related complications were defined as those necessitating additional interventions and leading to prolonged hospitalization. Finally, the causes of in-hospital mortality after radiofrequency catheter ablation were addressed.

**Patient Follow-Up**

Great majority of the patients (overall, 91.6%) already had implanted ICD or cardiac resynchronization therapy defibrillator devices. In the rest, ICD/cardiac resynchronization therapy defibrillator devices (4.5%) or implantable loop recorders (3.9%) were implanted before discharge. The patient follow-up for VT recurrence was performed in our pacemaker/ICD outpatient clinic through interrogation of the ICD or cardiac resynchronization therapy defibrillator devices. In 12-lead ECGs, we were able to identify ongoing VT below the detection of ICD in 11 patients (4.7%).

**Statistical Analysis**

For continuous variables with normal distribution, the mean values and standard deviations are reported; for categorical variables, absolute frequencies are used. The Student t test, \( \chi^2 \) test, and Fisher exact test were used to compare differences across different patient subgroups.

Separate univariate analysis was used to define the predictors for complete short-term success. We prespecified baseline and procedural characteristics that we believed to be associated with short-term outcome. Furthermore, a multivariable logistic regression model was used to determine independent predictors of complete short-term success with adjustment for baseline demographic and procedural characteristics. The odds ratios with corresponding 95% confidence intervals (CIs) and 2-sided \( P \) values of significance (\( P<0.05 \)) were presented.

For the long-term outcomes, VT recurrence–free survival was estimated by the Kaplan–Meier method, and log-rank statistics was used to compare the groups. The potential confounders were subsequently entered into the Cox proportional hazard model based on significant univariate association (2-sided \( P<0.05 \)). Multivariable Cox regression analysis was used to identify significant predictors of VT recurrence while controlling for clinically relevant covariates. All tests were 2 sided, and a value of \( P<0.05 \) was considered statistically significant.

The statistical analysis was performed with SPSS 17.0 (IBM, Armonk, NY).

**Results**

**Short-Term Procedural Success, Procedural Data, Complications, and In-Hospital Mortality**

Before the ablation, the VT was ongoing in 25 patients (11.7%), noninducible with programmed stimulation in 23 patients (10.7%), and inducible in 166 patients (77.6%). In 13 patients (5.7%), frequent monomorphic ventricular premature beats were initially targeted for ablation as presumptive

### Table 2. Procedure Characteristics and Short-term Outcomes

<table>
<thead>
<tr>
<th></th>
<th>NIDCM (n=63)</th>
<th>ICM (n=164)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMN, n (%)</td>
<td>5 (7.9)</td>
<td>59 (36)</td>
<td>0.0001</td>
</tr>
<tr>
<td>EMF MS, n (%)</td>
<td>60 (95.2)</td>
<td>154 (93.9)</td>
<td>0.699</td>
</tr>
<tr>
<td>Epicardial ablation, n (%)</td>
<td>19 (30.2)</td>
<td>2 (1.2)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Noninducible with PES, n (%)</td>
<td>9 (15.8)</td>
<td>14 (9.9)</td>
<td>0.360</td>
</tr>
<tr>
<td>Ongoing at beginning, n (%)</td>
<td>7 (12.3)</td>
<td>18 (11.5)</td>
<td>0.9</td>
</tr>
<tr>
<td>Substrate mapping/LP, n (%)</td>
<td>42 (66.7)</td>
<td>147 (89.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Activation mapping, n (%)</td>
<td>31 (63)</td>
<td>79 (48.5)</td>
<td>0.920</td>
</tr>
<tr>
<td>Entrainment, n (%)</td>
<td>17 (27)</td>
<td>17 (10.4)</td>
<td>0.002</td>
</tr>
<tr>
<td>Activation mapping, n (%)</td>
<td>31 (49.2)</td>
<td>79 (48.5)</td>
<td>0.921</td>
</tr>
<tr>
<td>VTs inducible, n/patient</td>
<td>2.1±1.23</td>
<td>2.16±1.32</td>
<td>0.744</td>
</tr>
<tr>
<td>VTs mappable, n/patient</td>
<td>1.6±0.80</td>
<td>1.96±0.80</td>
<td>0.06</td>
</tr>
<tr>
<td>VTs ablated, n/patient</td>
<td>1.40±1.11</td>
<td>1.64±1.15</td>
<td>0.168</td>
</tr>
<tr>
<td>Clinical VT CL, ms</td>
<td>364±86</td>
<td>385±93</td>
<td>0.133</td>
</tr>
<tr>
<td>Procedure time, min</td>
<td>181±63.6</td>
<td>155±49</td>
<td>0.003</td>
</tr>
<tr>
<td>Fluoroscopy time, min</td>
<td>39±22.4</td>
<td>26±19</td>
<td>0.0001</td>
</tr>
<tr>
<td>Ablation of all VTs, n (%)</td>
<td>42 (66.7)</td>
<td>127 (77.4)</td>
<td>0.125</td>
</tr>
<tr>
<td>Failure, n (%)</td>
<td>7 (11.1)</td>
<td>(4.9)</td>
<td>0.132</td>
</tr>
<tr>
<td>( \beta )-Blocker at discharge, n (%)</td>
<td>57 (90.5)</td>
<td>156 (95.1)</td>
<td>0.221</td>
</tr>
<tr>
<td>AAD at discharge, n (%)</td>
<td>26 (41.3)</td>
<td>52 (31.7)</td>
<td>0.212</td>
</tr>
</tbody>
</table>

Categorical data are presented as number and percentage; continuous data, as mean and standard deviation. A 2-sided value of \( P<0.05 \) indicates significance. AAD indicates antiarrhythmic drugs class I, II, or III at discharge; CL, cycle length; EMF MS, electromagnetic field–based mapping system; ICM, ischemic cardiomyopathy; LP, late potentials; NIDCM, nonischemic dilated cardiomyopathy; RMN, remote magnetic navigation; PES, programmed ventricular stimulation; and VT, ventricular tachycardia.
triggers for the clinical VTs. However, after elimination of the premature ventricular contractions, a repeated programmed electric stimulation was performed as an attempt to induce sustained VT. In cases of VT inducibility, elimination of the VTs was pursued as already described.

Patients with noninducible VTs (23 patients, 10.7%) were ablated on the basis of the underlying substrate, targeting fragmented and late potentials and comparing the paced morphology with the available 12-lead ECG when available. In 1 patient (4.3%), a VT with a cycle length consistent with the previously detected clinical VT was induced after radiofrequency catheter ablation. This tachycardia was further successfully ablated. In 4 of 23 patients (17.4%), nonclinical VTs (with cycle lengths faster than those in the ICD memory) were induced. They were classified as partial success.

The majority of patients in the ischemic group were ablated endocardially. Only 2 patients (1.2%) with ischemic VT were also ablated epicardially. In contrast, in the NIDCM group, significantly more patients (20 patients, 30.8%) required additional epicardial ablation (P=0.0001). Other statistically significant differences between NIDCM and ICM in terms of the ablation approach and use of mapping system or remote magnetic navigation are presented in Table 2.

Noninducibility of any VT (complete short-term success) was achieved in 42 NIDCM patients (66.7%) and in 128 patients ICM patients (77.4%; P=0.125). Ablation of the clinical tachycardia only (partial short-term success) was achieved in 14 NIDCM patients (22.2%) and 30 ICM patients (18.3%; P=0.574). Procedure failure was observed in 7 patients with NIDCM (11.1%) and in 8 patients with ICM (4.9%; P=0.132). There was no statistically significant difference in the short-term outcomes between the 2 groups.

The procedure time was significantly longer in the NIDCM group compared with the ICM group (181±64 versus 155±49 minutes, respectively; P=0.0001). Accordingly, the fluoroscopic time was also longer in NIDCM patients (39±22.4 minutes in NIDCM patients versus 26±19.1 minutes in ICM patients; P=0.0001).

At discharge, β-blockers were prescribed in 57 NIDCM patients (90.5%) and in 156 ICM patients (95.1%; P=0.221). AADs other than β-blockers were prescribed in 26 patients (41.3%) in the NIDCM group and in 52 patients (31.7%) in the ICM group (P=0.212). All procedural data, including the short-term success data, are presented in Table 2.

Three patients in the NIDCM group (3 of 63 patients, 4.8%) and 6 patients in the ICM group (6 of 164 patients, 3.7%) died during the hospital stay (P=0.7). One procedure-related death resulting from a left ventricular perforation and tamponade occurred in 1 patient with ICM (0.6%). Major procedure-related complications were observed in 7 patients (11.1%) in the NIDCM group and in 18 patients (11.1%) in the ICM group (P=1.0). With complications related to the femoral vascular access excluded, major complications were observed in 5 patients (8%) with NIDCM and in 10 patients (6%) with ICM. The complications and in-hospital mortality are presented in Table 3.

Predictors for the Short-Term Procedural Success
In the NIDCM population, multivariable logistic regression analysis identified epicardial ablation as an independent predictor for complete short-term success. Epicardial ablation increased the probability for complete ablation success, defined by noninducibility of any VT (odds ratio, 10.5; 95% CI, 2.52–44; P=0.001). The number of VTs induced during the procedure, on the other hand, decreased the short-term success rate with an odds ratio of 0.46 (95% CI, 0.26–0.82; P=0.008) for every additional VT.

In the ICM group, the number of VT morphologies inducible during the procedure was associated with an unfavorable ablation success. For each additional VT inducible during the procedure, the odds for complete short-term success decreased with an odds ratio of 0.61 (95% CI, 0.45–0.82; P=0.001). No other variables (age, electric storm, VT cycle length, ejection fraction) in the model were independent predictors of successful ablation (Figure 1).

Long-Term Success Rate and All-Cause Mortality
The median follow-up in ICM was nonsignificantly longer compared with NIDCM (ICM: 27 months; first–third quartiles, 15.75–37.0 months; NIDCM: 20 months; first–third quartiles, 16.0–35.5 months). At the end of the follow-up period, the cumulative VT-free survival was 43.0% for ICM versus 23.0% for NIDCM. At the 1-year follow-up, the VT-free survival in ICM was 57% versus 40.5% in NIDCM. The univariate analysis showed that the hazard ratio (HR) for VT recurrence was significantly higher for the NIDCM group (HR, 1.62; 95% CI, 1.12–2.34; P=0.01). Notably, both curves have a very steep slope at the beginning, representing the high recurrence rate
early after ablation. Early reablation during the same hospital stay was performed in 19 patients (8.4%). First VT recurrence after the index ablation was accepted as an end point; these cases were censored, and the Kaplan–Meier curves do not represent patients with repeated ablations or newly instituted antiarrhythmic therapy. The longer follow-up was expectedly associated with a further reduction in the cumulative VT-free survival but with a diminished slope of the Kaplan–Meier curves. In multivariable Cox regression analysis for the relevant confounders (age, arterial hypertension, epicardial ablation, use of remote magnetic navigation, substrate mapping, procedure time, complete short-term success), the estimated HR for the VT recurrence was 1.73 (95% CI, 1.029–2.905; \(P=0.039\); Figure 2).

During the follow-up period, death resulting from all causes occurred in 8 patients (8 of 63 patients, 12.7%) in the NIDCM group and in 13 patients (13 of 164 patients, 7.9%) in the ICM group. Although higher in the NIDCM group, the all-cause mortality difference did not reach statistical significance (\(P=0.307\)).

Predictors of Long-Term Outcome: VT Recurrence

In Cox regression analysis, ablation failure and partial success were the only 2 independent predictors of VT recurrence in the NIDCM subgroup. Procedure failure was associated with a 4-fold increased probability for VT recurrence (HR, 4.13; 95% CI, 1.56–10.9; \(P=0.004\)). The partial success also was associated with an increased probability for VT recurrence (HR, 3.28; 95% CI, 1.25–8.65; \(P=0.0016\); Table 4).

In the ICM subgroup, both procedure failure and partial success were independent predictors of VT recurrence. The procedure failure was associated with a >4-fold increased probability for VT recurrence (HR, 4.48; 95% CI, 1.21–16.65; \(P=0.025\)). The probability for VT recurrence in patients with partially successful ablation was almost 2-times higher compared with those with completely successful ablation (HR, 1.9; 95% CI, 1.004–3.58; \(P=0.048\)). Additionally, heart failure severity and younger age were predictors of unfavorable outcome (Table 4).

Discussion

Data on the short- and long-term outcomes of VT ablation in NIDCM are scarce. This study aimed to prospectively compare the outcomes of VT radiofrequency catheter ablation in large groups of patients with NIDCM and ICM. In contrast to previously published reports, in our study, AAD discontinuation was pursued in most patients, with ≈40% of the
NIDCM patients and 30% of the ICM patients left on AADs at discharge. In conjunction with the prolonged follow-up, this gives a realistic appreciation of the long-term ablation outcomes in NIDCM compared with ICM.

Although the present study comprises patients with significantly dilated ventricles and impaired ejection fraction suggesting a vast arrhythmogenic substrate, complete elimination of any VT was achieved in nearly 67% of NIDCM patients compared with 77% of the ICM patients. Additionally, ablation of the clinical tachycardia was achieved in 22% of the NIDCM patients and in 18% of the ICM patients. These results are in line with published data from earlier studies and proved fairly good immediate success rates in both NIDCM and ICM.1–13

Additional epicardial ablation was an independent predictor of short-term success in the overall cohort and in NIDCM patients. This finding was expected because previous research in idiopathic DCM using electroanatomic mapping and magnetic resonance imaging demonstrated more extensive epicardial involvement in idiopathic DCM.20–22 In

Table 4. Multivariable Regression Analysis for the VT Recurrence in NIDCM and ICM

<table>
<thead>
<tr>
<th></th>
<th>NIDCM, HR; 95% CI</th>
<th>p Value</th>
<th>ICM, HR; 95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.98; 0.95–1.015</td>
<td>0.278</td>
<td>0.97; 0.95–0.99</td>
<td>0.038</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td></td>
<td></td>
<td>1.3; 0.77–2.24</td>
<td>0.313</td>
</tr>
<tr>
<td>Heart failure, NYHA class I–IV</td>
<td>1.02; 0.63–1.66</td>
<td>0.929</td>
<td>1.36; 1.02–1.81</td>
<td>0.034</td>
</tr>
<tr>
<td>EF, %</td>
<td>1.003; 0.97–1.03</td>
<td>0.853</td>
<td>0.98; 0.96–1.007</td>
<td>0.172</td>
</tr>
<tr>
<td>Failure vs complete success</td>
<td>4.12; 1.56–10.89</td>
<td>0.004</td>
<td>4.48; 1.2–16.65</td>
<td>0.025</td>
</tr>
<tr>
<td>Partial vs complete success</td>
<td>3.28; 1.25–8.65</td>
<td>0.016</td>
<td>1.9; 1.004–3.58</td>
<td>0.048</td>
</tr>
<tr>
<td>No. of VTs</td>
<td>1.13; 0.83–1.53</td>
<td>0.443</td>
<td>1.2; 0.98–1.47</td>
<td>0.076</td>
</tr>
<tr>
<td>Epicardial ablation</td>
<td>1.86; 0.76–4.53</td>
<td>0.172</td>
<td></td>
<td></td>
</tr>
<tr>
<td>β-Blocker</td>
<td>2.04; 0.63–6.62</td>
<td>0.236</td>
<td>1.02; 0.24–4.3</td>
<td>0.975</td>
</tr>
<tr>
<td>AAM</td>
<td>0.48; 0.22–1.07</td>
<td>0.072</td>
<td>1.71; 0.94–3.1</td>
<td>0.079</td>
</tr>
</tbody>
</table>

This table presents the multivariable analysis for VT recurrence in the NIDCM and ICM groups. The HRs with the corresponding 95% CIs and pValues are presented. Procedure failure and partial success are independent predictors of VT recurrence in both NIDCM and ICM (2-sided P<0.5). Additionally, heart failure severity and younger age are predictors of VT recurrence during the follow-up period. AAM indicates antiarrhythmic medication other than β-blocker; CI, confidence interval; EF, ejection fraction; HR, hazard ratio; ICM, ischemic cardiomyopathy; NIDCM, nonischemic dilated cardiomyopathy; NYHA, New York Heart Association; and VT, ventricular tachycardia.
the ICM group, because of the small number of epicardially ablated patients (2 patients), both of them with long-term success, it was not possible to assess the effects of epicardial ablation in the logistic regression model. Previously, Soejima et al\textsuperscript{11} reported poorer success after endocardial ablation of VT in DCM compared with ICM patients. More recent studies demonstrated that additional epicardial ablation significantly improved the short-term ablation success in conditions like DCM, arrhythmogenic right ventricular cardiomyopathy, and more recently ICM.\textsuperscript{13,15,22} Some authors recommend complete endocardial and epicardial scar homogenization to improve the short- and long-term clinical success in ICM patients.\textsuperscript{23} We believe that a similar ablation strategy based on substrate delineation, late potentials ablation, and scar modification is not always applicable in NIDCM. We demonstrated that late potentials and substrate-guided ablation was possible in no more that 66% of NIDCM patients compared with almost 90% in ICM patients. Similar observations were demonstrated in previous studies, suggesting differences in the electroanatomic properties, with less frequently observed late potentials in the NIDCM patients.\textsuperscript{18} Therefore, a more complex ablation approach, combining substrate mapping with reentry circuit characterization using entrainment and activation mapping, should be used in NIDCM to achieve better short-term success rates.

Our data support the concept of pursuing epicardial ablation as a second step if VT remains inducible after endocardial ablation in NIDCM patients. Considering the higher complication risk associated with epicardial ablation, this strategy could be a reasonable approach compared with a mandated endocardial and epicardial approach, as some authors now advocate.\textsuperscript{13,20}

At the long-term follow-up, freedom from any VT was observed in 57% of the patients in ICM by the end of the first year and in 43% of the cases by the end of the follow-up, extended up to 3 years. This outcome is comparable to already published data in the biggest multicenter trials. In the Multicenter Thermocool Ventricular Tachycardia Ablation trial, the reported VT recurrence was 47% at 6 months; however, >70% of the patients were on AADs and 50% were on amiodarone.\textsuperscript{3} The reported VT recurrence in the multicenter, prospective, randomized Ventricular Tachycardia Ablation in Coronary Heart Disease (VTACH) study was 47% in the ablation arm. In VTACH and in the present trial, the antiarrhythmic medication was discontinued in the majority of patients.\textsuperscript{1}

Compared with ICM, the long-term success rates in NIDCM were significantly worse, although a recent trial described comparable long-term outcomes in ICM and NIDCM.\textsuperscript{13} In particular, the Kaplan–Meier curves for VT-free survival in both groups exhibited a very steep slope initially, representing a higher recurrence rate early after ablation. A possible explanation may be the rigorous in-hospital monitoring that allows detection of all early VT recurrences. As expected, the longer follow-up period was associated with further reduction in the cumulative VT-free survival but with a much steeper slope for NIDCM, so that at the end of the follow-up period, >75% of the NIDCM patients had recurrence of sustained VT. Similar outcomes in NIDCM were described in earlier studies with a shorter follow-up and limited number of patients. Soejima et al\textsuperscript{11} reported a 46% recurrence rate in a small cohort of DCM patients with shorter follow-up. The cause for this striking difference in the long-term outcomes between NIDCM and ICM, despite comparable short-term success rates, must be sought in the peculiarities of arrhythmia substrate in NIDCM.\textsuperscript{18,20,22} In one of the largest autopsy series in idiopathic DCM, only 14% of 152 patients with idiopathic DCM had evidence of grossly visible left ventricular scar; however, 57% of the analyzed specimens demonstrated histological evidence for interstitial or replacement fibrosis.\textsuperscript{22}

We should also recognize the fact that VT ablation is a transient step that could modify the existing substrate at the time of the procedure but could not impede the progression of disease and formation of new substrate or new triggers. We believe that the concept of a “fixed” underlying morphological substrate is probably true for the postinfarction cardiomyopathy, whereas in NIDCM there are unknown factors leading to the progression and modification of the arrhythmia substrate over time.

The importance of VT noninducibility as a procedural end point for the long-term freedom from VT is controversial. In previous studies in patients with VTs of ischemic origin, failure and partial success of the ablation procedure were associated with an increased VT recurrence.\textsuperscript{5,7} Such a relationship was not found in other studies in coronary artery disease, possibly because of differences in short- and long-term success definitions and stimulation protocols and the influence of frequently used AADs after ablation.\textsuperscript{1–3} However, data on VT noninducibility and its impact on the long-term success in NIDCM are not available. In the present study, procedure failure and partial success were strongly associated with unfavorable long-term outcomes in both NIDCM and ICM. Determining the so-called clinical VT is difficult in many cases, and partial success is an unreliable ablation end point, as our findings also suggested. Therefore, we believe that elimination of all inducible VTs should be pursued in the absence of other appropriate end points.

**Study Limitations**

This study is a single-center, nonrandomized study and represents the experience of 3 skillful operators. Still, the impact of the learning curve and the evolution in the available technology on the outcome was not evaluated. A second limitation is that the study represents outcomes after a single VT ablation, and in some cases, a repeated VT ablation could change the long-term outcomes. The study represents a population with an advanced stage of left ventricular remodeling and impaired systolic function; hence, the outcomes in patients ablated in an earlier stage of the disease may be different from those presented in this study. The impact of stimulation site in relation to scar localization was not taken into account. The impossibility of inducing VT with programmed stimulation at both the beginning and end of ablation in some patients makes the definition of short-term success in these cases uncertain and may have an impact on the short-term success.
Conclusions
Although the short-term success rates after VT ablation in ICM and NIDCM are similar, the long-term outcomes in NIDCM are significantly worse. Procedure failure and partial success are associated with an increased probability for VT recurrence. Epicardial ablation is an independent predictor for complete short-term success in NIDCM. Additionally, fewer low-voltage areas and late potentials were observed in NIDCM patients. Therefore, a more comprehensive approach that includes entrainment, repeated ablations, and epicardial mapping while aiming for complete VT noninducibility should be adopted in NIDCM.

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Data on the outcomes of ventricular tachycardia (VT) ablation in nonischemic dilated cardiomyopathy (NIDCM) are insufficient. The Heart Center of Leipzig VT (HELP-VT) study is a large, prospectively conducted trial including >220 patients that aimed to compare outcomes after radiofrequency catheter ablation of VT in patients with NIDCM compared with ischemic cardiomyopathy. We found that even though the short-term success rates after VT ablation in NIDCM and ischemic cardiomyopathy are similar, the long-term outcomes in NIDCM were significantly worse. Substrate-guided ablation has limitations resulting from the low incidence of late potentials and endocardial scar areas. Complete VT noninducibility at the end of the ablation is associated with beneficial long-term outcome in NIDCM. Pursuing complete elimination of all inducible VTs with epicardial mapping and ablation, when necessary, may be beneficial to achieve a better long-term success in NIDCM.
Outcomes in Catheter Ablation of Ventricular Tachycardia in Dilated Nonischemic Cardiomyopathy Compared With Ischemic Cardiomyopathy: Results From the Prospective Heart Centre of Leipzig VT (HELP-VT) Study

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