Outcomes in Catheter Ablation of Ventricular Tachycardia in Dilated Non-Ischemic Cardiomyopathy in Comparison to Ischemic Cardiomyopathy:
Results from the Prospective HEart Centre of LeiPzig VT (HELP – VT) Study

Running title: Dinov et al.; Outcomes after RFCA of VT in NIDCM vs. ICM

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Abstract

Background—Data on the outcomes of ventricular tachycardia (VT) ablation in non-ischemic dilated cardiomyopathy (NIDCM) are insufficient. The HEart centre of LeiPzig VT (HELP-VT) study was prospectively conducted to compare outcomes after radiofrequency catheter ablation (RFCA) of VT in patients with NIDCM as compared to ischemic cardiomyopathy (ICM).

Methods and Results—Two hundred and twenty-seven (227) patients with NIDCM (63 pts.) and ICM (164 pts.), presenting with sustained VT were ablated using RFCA. Non-inducibility of any clinical and non-clinical VT was achieved in 66.7% in NIDCM and in 77.4% in ICM. Ablation of the clinical VT only was achieved in 18.3% in ICM and in 22.2% in DCM. There was no statistically significant difference in the acute outcome between the two groups. At one year follow-up, the VT free survival in NIDCM was 40.5% versus 57% in ICM. In univariate analysis, the hazard ratio for VT recurrence was significantly higher for the NIDCM (HR 1.62; CI 95% 1.12–2.34; p = 0.01). In both ICM and NIDCM subgroups, the procedure failure and incomplete procedural success were independent predictors for VT recurrence.

Conclusions—Even though the acute success after VT ablation in NIDCM and ICM was similar, the long-term outcomes in NIDCM were significantly worse. Complete VT non-inducibility at the end of the ablation associates with beneficial long-term outcome in NIDCM. Pursuing compete elimination of all inducible VTs is desirable and may improve the long–term success in NIDCM.

Key words: ventricular tachycardia, dilated cardiomyopathy, radiofrequency, ablation
Evidence supporting the effectiveness and safety of radiofrequency catheter ablation (RFCA) of ventricular tachycardia (VT) is primarily based on data from two randomized prospective multicenter studies and some single-center and non-randomized studies in patients with coronary artery disease (CAD).\textsuperscript{1,2,3,4,5,6} The reported variability in the ablation outcomes in these studies reflects the differences in the ablation approach, the definitions of acute and long-term success, and the use of different anti-arrhythmic drugs (AAD) after ablation.\textsuperscript{1,2,3,4,5,6,7} Studies addressing the outcomes in NIDCM patients are fewer, comprise smaller groups of patients, and have reported worse outcomes.\textsuperscript{8,9,10,11,12} A more recent multi-center trial in epicardial VT ablation suggested comparable outcomes in ICM and NIDCM, with a reported VT recurrence in 39.3% in NIDCM versus 34.7% in ICM.\textsuperscript{13}

There is also great uncertainty about the determinants and predictors of acute 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 non-inducibility as an independent predictor of long–term VT-free survival, while others failing to demonstrate such dependency\textsuperscript{2,3,4,5,6,7} Data on NIDCM are even more scarce. In a recent study in patients with NIDCM VT, non–inducibility failed to predict long-term success even after epicardial ablation.\textsuperscript{12}

The HEart centre of LeiPzig VT (HELP-VT) study was conducted prospectively to compare the outcomes after RFCA of VT in NIDCM and ICM. Further, we sought to determine the predictors for the acute and long-term success rate in NIDCM.

Methods

Definitions of ICM and NIDCM

The distinction between ICM and NIDCM was based primary on the presence of relevant...
coronary artery disease confirmed with a coronary angiography. NIDCM was identified as absence of relevant CAD and according to the criteria of the European Society of Cardiology Working Group for Myocardial and Pericardial Diseases. Patients with acquired DCM due to toxic agents, nutritional causes, or systemic and endocrine diseases were excluded from the study. The rational behind this was that secondary myocardial damage due to toxic, nutritional or endocrine causes could be reversible after elimination of the primary cause. Also some toxic substances could induce VTs with a non–re-entrant mechanism (digitalis, daunorubizin and etc).

**Patient Population**

Based on the above mentioned definitions, two hundred and twenty-seven (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 pts; 28.1%), presenting with recurrent sustained VT were enrolled in the study. Baseline and procedure data were derived from the HEart centre of LeiPzig VT Registry (HELP – VT). All patients were ablated using radiofrequency energy in the period between January 2008 and December 2011. In cases with more than one VT ablation, the first procedure was taken as an index ablation. Cases with bundle-branch re-entry VT were also excluded from the study, because of the different electrophysiological mechanisms and ablation approaches. In the overall population, two hundred and eight (208 pts, 91.6%) patients had implanted ICD or CRT-D devices; one hundred and one patients (101 pts, 44.5%) presented with electrical storm, defined as more than 3 VTs, requiring ICD-therapy (ATPs and/or shocks) or external defibrillation in 24 hours.

At admission, one hundred and fifty-six patients (156 pts; 95.1%) with ICM were on beta-blocker therapy vs. fifty seven patients (57 pts; 90.5%) with NIDCM; p = 0.221. At admission, twenty one patients with NIDCM (21 pts.; 33.3%) were on amiodarone therapy vs.
sixty four patients (64 pts; 39%) in ICM; p = 0.448. Patient characteristics for NIDCM and ICM are summarized in Table 1.

**Endocardial vs. Epicardial Access**

All patients signed an 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. Since a significant proportion of cases were ablated in emergency settings, the withdrawal of the AAD, mainly amiodaron, 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 only used occasionally. The technique for transseptal puncture was performed, using a steerable introducer (Agilis™, St. Jude Medical, St. Paul, MN, USA). The decision for epicardial approach was taken based on the ventricular tachycardia QRS morphology in 12 lead ECG, and/or if a prior endocardial attempt failed to abolish the VT, and/or the endocardial voltage mapping revealed no dense confluent scar. The technique for the subxyphoid puncture is described in details elsewhere. In cases where endo- and epicardial mapping appear to be necessary, the subxyphoid puncture was performed first in order to avoid inadvertent bleeding complications. After entering the left ventricular cavities heparin was administered to maintain an activation clothing time of over 300 seconds.

**Programmed electrical stimulation**

Data were recorded using a multichannel recording system (Prucka CardioLab, GE Healthcare, USA). If not ongoing, an attempt to induce either clinical and/or non-clinical monomorphic VT
was performed. We used programmed electrical stimulation (PES) from right ventricular apex and outflow tract with four different drive cycle lengths (500, 430, 370, 330 ms) and introduction of up to 3 extrastimuli until the ventricular ERP or coupling interval of 200 ms. If not inducible, additional stimulation in the left ventricle was performed. The same induction protocol was used to re–induce the VT after ablation. Isoproterenol was not used in our stimulation protocol.

**Electroanatomical mapping and catheter ablation**

Catheter mapping was performed in sinus rhythm using fluoroscopy and electronatomical 3D mapping system (Carto 3, Biosense Webster Inc., CA, USA or EnSite, St. Jude Medical, MN, USA). 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 dilated cardiomyopathy frequently involves the epicardial layers, epicardial mapping and ablation was performed more frequently in NIDCM patients compared to 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 ms, demonstrating fractionation with ≥ 2 components and/or demonstrating late potentials with an onset well after the QRS.\(^{18}\)

Radiofrequency energy was used for ablation with open-irrigated tip ablation catheters with power settings of up to 50 W and irrigation rate of up to 30 ml/min (Thermocool, Biosense Webster Inc, Diamond bar, CA, USA), or 50 W and flow rate of 15 ml/min (Thermocool SF,
Biosense Webster Inc, Diamond bar, CA, USA). In cases where the EnSite NavX system was used, we used an irrigated tip Coolflex catheter with 50 W and 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 endpoints**

Ablation endpoints were defined according to the latest guideline recommendations. Ablation of the clinical VT only was defined as partial acute success. Clinical tachycardia was determined based on the available 12 lead ECG or VT cycle length in the ICD memory. Far-field EGM morphology was not routinely taken in consideration to distinguish the VT morphology. Other non-clinical monomorphic and hemodynamically stable VTs inducible during the procedure were also targeted for ablation. Complete elimination of any clinical and non-clinical stable monomorphic VT was defined as complete acute success. Re-induction of clinical and non-clinical VTs despite ablation was defined as procedure failure. VT recurrence was defined as any episode of sustained VT occurring after the ablation procedure, requiring ICD-therapy and/or detected in monitor zone of ICD, and/or in ECG. Major procedure-related complications were defined as those, necessitating additional interventions and leading to prolonged hospitalization. Lastly, the causes of in-hospital mortality after RFCA were addressed.

**Patient follow-up**

Great majority of the patients (overall 91.6%) had already implanted ICD or CRT-D devices. In the rest, ICD/CRT-D devices (4.5%) or ILRs (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 devices. Using 12-lead ECG we were able to identify ongoing VT below the detection of ICD in 11 patients (4.7%).
Statistical analysis

For the continuous variables with normal distribution, the mean values and standard deviations are reported, while for categorical variables, absolute frequencies are used. Student t test, chi-square test, and Fischer exact test were used to compare differences across different patient subgroups.

Separate univariate analysis was used to define the predictors for acute complete success. We pre-specified baseline and procedural characteristics that were believed to be associated with acute outcome. Further, multivariable logistic regression model was used to determine independent predictors of acute complete success with adjustment for baseline demographic and procedural characteristics. The odds ratios (OR) with corresponding 95% confidence intervals (CI) and two-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 for identifying significant predictors of VT recurrence while controlling for clinically-relevant covariates. All tests were two-sided, and p value of < 0.05 was considered statistically significant.

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

Results

Acute procedural success, procedural data, complications and in-hospital mortality

Before the ablation, the VT was ongoing in twenty five patients (25 pts, 11.7%), non-inducible with programmed stimulation in twenty-three (23 pts, 10.7%) and inducible in hundred and sixty
six patients (166 pts, 77.6%). In thirteen patients (13 pts, 5.7%) frequent monomorphic ventricular premature beats were initially targeted for ablation as presumptive triggers for the clinical VTs. However, after elimination of the PVCs, a repeated PES was performed, as an attempt to induce sustain VT. In cases of VT inducibility, elimination of the VTs was pursued as already described.

Patients with non-inducible VTs (23 pts; 10.7%) were ablated based on the underlying substrate, targeting fragmented and late potentials, and comparing the paced morphology to the available 12-lead ECG, where available. In one patient (4.3%) a VT with a cycle length consistent with the previously detected clinical VT was induced after RFCA. This tachycardia was further successfully ablated. In four from 23 patients (17.4%), non-clinical VTs (with cycle lengths faster than those in the ICD memory) were induced. They were classified as partial success.

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

Non-inducibility of any VT (acute complete success) was achieved in forty two (42 pts, 66.7%) NIDCM patients and in one hundred and twenty-eight (128 pts, 77.4%) ICM patients; p=0.125. Ablation of the clinical tachycardia only (acute partial success) was achieved in fourteen NIDCM patients (14 pts, 22.2%) and thirty ICM patients (30 pts, 18.3%); p=0.574. Procedure failure was observed in seven patients with NIDCM (7 pts, 11.1%) and in eight
patients with ICM (8 pts, 4.9%); p=0.132. There was no statistically significant difference in the acute outcomes between the two groups.

The procedure time was significantly longer in NIDCM group compared to the ICM group: (181±64 min vs. 155±49 min resp., p =0.0001). Accordingly, the fluoroscopic time was also longer in NIDCM: (39 ± 22.4 min in NIDCM vs. 26 ± 19.1 min in ICM, p=0.0001).

At discharge, beta–blockers were prescribed in fifty seven (57 pts, 90.5%) of NIDCM patients and in one hundred and fifty-six (156 pts, 95.1%) of ICM patients (p=0.221). AAD, other than beta-blockers, were prescribed in twenty six (26 pts, 41.3%) in NIDCM and in fifty two (52 pts, 31.7%) in ICM (p=0.212). All procedural data, including the acute success data are presented in table 2.

Three patients in the NIDCM group (3/63 pts; 4.8%) and six patients (6/164 pts; 3.7%) in the ICM group died during the hospital stay (p=0.7). One procedure-related death due to a LV perforation and tamponade occurred in one case in ICM (0.44%). Major procedure-related complications were observed in seven (7 pts, 11.1%) patients in NIDCM group and in eighteen (18 pts, 11.1%) patients in ICM group (p=1.0). Excluding complications related to the femoral vascular access, major complications were observed in five patients (5 pts, 8%) with NIDCM, and in ten patients (10 pts, 6%) with ICM. The complications and in-hospital mortality are presented in table 3.

**Predictors for the acute procedural success**

In the NIDCM population, the multivariable logistic regression analysis identified epicardial ablation as an independent predictor for acute complete success. Epicardial ablation increased the probability for complete ablation success, defined by non-inducibility of any VT: (OR 10.5; CI 95% 2.52 – 44; p=0.001). The number of VTs induced during the procedure, on the other
hand, decreased the acute success rate with an OR of 0.46 for every additional VT: (OR 0.46; CI 95% 0.26-0.82; p=0.008).

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 acute success decrease with an OR of 0.61; CI 95% 0.45 – 0.82; p=0.001. No other variables (age, electrical 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 non-significantly longer compared to NIDCM: (27 months; 1st-3rd quartile – 15.75 – 37.0 for ICM and 20 months; 1st – 3rd quartile – 16.0 - 35.5 months for NIDCM). At the end of the follow-up period, the cumulative VT-free survival was 43.0% for ICM versus 23.0% for NIDCM. At one year follow-up, the VT-free survival in ICM accounts for 57% versus 40.5% in NIDCM. The univariate analysis showed the hazard ratio for VT recurrence being significantly higher for the NIDCM group (HR 1.62; CI 95% 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 re-ablation during the same hospital stay was performed in 19 (8.4%) patients. First VT recurrence after the index ablation was accepted as an end-point; these cases were censored and the Kaplan – Meyer curves do not represent patients with repeated ablations and/or newly instituted antiarrhythmic therapy. The longer follow-up was expectedly associated with further reduction in the cumulative VT free survival, but with a diminished slope of the Kaplan – Meyer curves. In multivariable Cox regression analysis for the relevant confounders (age, arterial hypertension, epicardial ablation, use of remote magnetic navigation, activation mapping, procedure time, acute complete success) the estimated HR for
the VT recurrence was 1.73; CI 95% 1.029 – 2.905; p=0.039 (Fig. 2).

During the follow-up period, death from all causes occurred in eight patients (8/63 pts, 12.7%) in the NIDCM group and in thirteen patients (13/164 pts, 7.9%) in the ICM group. Even though higher in 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 two independent predictors of VT recurrence in the NIDCM subgroup. The 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 was associated with an increased probability for VT recurrence as well: 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 more than 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 to completely successful ablation: HR 1.9; 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 acute and long-term outcomes of VT ablation in NIDCM are scarce. This study aimed to prospectively compare the outcomes of VT RFCA 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 approximately 40% of the patients with NIDCM and 30% of
the ICM patients left on AAD at discharge. In conjunction with the prolonged follow-up this gives a realistic appreciation of the long-term ablation outcomes in NIDCM, compared to the ICM.

Even though the present study comprises of 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 vs. 77% of the ICM patients. Additionally, ablation of the clinical tachycardia was achieved in 22% of NIDCM patients and in 18% of ICM patients. These results are in line with published data in earlier studies and proved a fairly good immediate success rates in both NIDCM and ICM.\textsuperscript{1,2,3,4,5,6,7,8,9,10,11,12,13}

Additional epicardial ablation was an independent predictor of acute success in the overall cohort and in NIDCM patients. This finding was expected, since previous research in idiopathic DCM, using electro-anatomical mapping and magnetic resonance imaging, demonstrated more extensive epicardial involvement in idiopathic dilated cardiomyopathy.\textsuperscript{20,21,22} In 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. reported poorer success after endocardial ablation of VT in DCM compared to ICM patients.\textsuperscript{11} More recent studies demonstrated that additional epicardial ablation significantly improved the acute ablation success in conditions like DCM, ARVC, and more recently ICM.\textsuperscript{11,13,23,24,25,26} Some authors recommend complete endocardial and epicardial scar homogenisation to improve the acute and long-term clinical success in ICM patients.\textsuperscript{23} We believe, that 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% in NIDCM patients, compared to almost 90% in ICM patients. Similar observations were demonstrated in previous studies, suggesting differences in the electro-anatomical properties, with less frequently observed late potentials, in the NIDCM patients. Therefore, more complex ablation approach, combining substrate mapping with re-entry circuit characterization, using entrainment and activation mapping, should be used in NIDCM to achieve better acute 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 complications risk associated with epicardial ablation, this strategy could be a reasonable approach, when compared to a mandated endo– and epicardial approach, as some authors now advocated.13,20

At 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 more than 70% of the patients were on AAD, and 50% on amiodaron.3 The reported VT recurrence in the multicenter prospective and randomized VTACH study was 47% in the ablation arm. In VTACH, as well as in the present trial, the antiarrhythmic medication was discontinued in the majority of patients.1

In comparison to ICM, the long-term success rates in NIDCM were significantly worse, although a recent trial described comparable long-term outcomes in ICM and NIDCM13. In particular, the Kaplan – Meyer curves for VT-free survival in both groups exhibited a very steep slope initially, representing higher recurrence rate early after ablation. A possible explanation
may be the rigorous in-hospital monitoring that allows for 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 the NIDCM, such that at the end of the follow-up period, more than 75% of the patients with NIDCM have recurrence of sustained VT. Similar outcomes in NIDCM were described in earlier studies with shorter follow-up and limited number of patients. Soejima et al. reported 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 acute success rates, must be sought in the peculiarities of arrhythmia substrate in NIDCM. 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 histologic evidence for interstitial or replacement fibrosis.

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 and/or new triggers. We believe that the concept of a “fixed” underlying morphological substrate is probably true for the post-infarction cardiomyopathy, while in NIDCM there are unknown factors leading to progression and modification of the arrhythmia substrate over time.

The importance of VT non-inducibility, as a procedural end-point, for the long-term freedom from VT is controversial. In previous studies in patients with VTs of ischemic origin, the failure and partial success of the ablation procedure were associated with an increased VT recurrence. Such relationship was not found in other studies in CAD, possibly because of differences in acute and long-term success definitions, stimulation protocols, as well as the
influence of frequently used AAD after ablation. However, data on the VT non-inducibility and its impact on the long-term success in NIDCM are not available. In the present study, the 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 absence of other appropriate end-points.

**Study limitations**

The study is a single-center non-randomized study and represents the experience of three skillful operators. Still the impact of the learning curve and the evolution in the available technology on the outcome was not evaluated. Second limitation is that the study represents outcomes after a single VT ablation, and in some of the cases a repeated VT ablation could change the long-term outcomes. The study represents a population with an advanced stage of LV remodeling and impaired systolic function, hence the outcomes in patients ablated in an earlier stage of the disease may be different from these presented in this study. The impact of stimulation site in relation to the scar localization was not taken into account. Impossibility to induce VT with programmed stimulation both at the beginning and at the end of ablation in some patients makes the definition of acute success in these cases uncertain and may have an impact on the acute success.

**Conclusion**

Even though the acute success rates after VT ablation in ICM and NIDCM are similar, the long-term outcomes in NIDCM are significantly worse. The procedure failure and partial success are
associated with an increased probability for VT recurrence. Epicardial ablation is an independent predictor for acute complete success in NIDCM. Additionally, less low-voltage areas and late potentials were observed in NIDCM patients. Therefore, a more comprehensive approach including entrainment, repeated ablations, epicardial mapping, while aiming for complete VT non-inducibility should be adopted in NIDCM.

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**Conflict of Interest Disclosures:** Borislav Dinov, Arash Arya, Lukas Fiedler, Robert Schönbauer, Andreas Bollmann, Sascha Rolf have no conflict of interest to declare. Christopher Piorkowski has received modest lecture honoraria and congress sponsoring from St Jude Medical and Biosense Webster and is a member of the St Jude Medical and Biosense Webster advisory board.

**References:**


infarction ventricular tachycardia. Long-term outcome in relation to acute electrophysiological findings. 


Table 1. Baseline clinical characteristics

<table>
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<th></th>
<th>NIDCM N 63</th>
<th>ICM N 164</th>
<th>P</th>
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<tr>
<td>Age, y</td>
<td>59.2±13.47</td>
<td>67.4±10.09</td>
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<td>Gender, male, n (%)</td>
<td>52 (82.5)</td>
<td>142 (88.4)</td>
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<td>Atrial fib/flutter, n(%)</td>
<td>30 (47.6)</td>
<td>83 (50.6)</td>
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<td>ICD/CRT-D, n(%)</td>
<td>60 (95.2)</td>
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<td>Electrical storm, n(%)</td>
<td>34 (54)</td>
<td>67 (40.9)</td>
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<td>BB at admission, n(%)</td>
<td>57 (90.5)</td>
<td>156 (95.1)</td>
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<td>Amiod. at admission, n(%)</td>
<td>21 (33.3)</td>
<td>64 (39)</td>
<td>0.448</td>
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<td>Art. Hypertension, n(%)</td>
<td>30 (47.6)</td>
<td>135 (82.3)</td>
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<td>Diabetes mellitus, n(%)</td>
<td>18 (28.6)</td>
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<td>Heart failure &gt;2 NYHA, n(%)</td>
<td>34 (55.7)</td>
<td>91 (63.2)</td>
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<td>LV EF %</td>
<td>33.7 ± 11.09</td>
<td>32.3 ± 11.26</td>
<td>0.414</td>
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</table>

Legend: Atrial fib/flutter = atrial fibrillation/flutter; BB = beta blockers at admission; Amiod. = amiodarone at admission.

Categorical data are presented as number and percentage; continuous data as mean and standard deviation (SD); two-sided p value < 0.05 indicate significance.
Table 2. Procedure characteristics and acute outcome

<table>
<thead>
<tr>
<th></th>
<th>NIDCM</th>
<th>ICM</th>
<th>P</th>
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<tbody>
<tr>
<td></td>
<td>N 63</td>
<td>N 164</td>
<td></td>
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<tr>
<td>RMN; n(%)</td>
<td>5 (7.9)</td>
<td>59 (36)</td>
<td>0.0001</td>
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<td>60 (95.2)</td>
<td>154 (93.9)</td>
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<td>Epicardial ablation; n(%)</td>
<td>19 (30.2)</td>
<td>2 (1.2)</td>
<td>0.0001</td>
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<td>Non-induc. 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>No VTs inducible/patient</td>
<td>2.1 ± 1.23</td>
<td>2.16 ± 1.32</td>
<td>0.744</td>
</tr>
<tr>
<td>No VTs mapable/patient</td>
<td>1.61 ± 0.80</td>
<td>1.96 ± 0.80</td>
<td>0.06</td>
</tr>
<tr>
<td>No VTs ablated/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>BB at discharge, n(%)</td>
<td>51 (90.5)</td>
<td>136 (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>

Legend: RMN = remote magnetic navigation; EMF MS = electromagnetic field-based mapping system; PES = programmed ventricular stimulation; BB = beta-blockers at discharge; AAD = antiarrhythmic drugs class I, II, III at discharge

Categorical data are presented as number and percentage; continuous data as mean and standard deviation (SD); two-sided p value < 0.05 indicate significance.
Table 3. Procedure related complications and in–hospital mortality

<table>
<thead>
<tr>
<th>Major complications, n (%)</th>
<th>NIDCM N 63</th>
<th>ICM N 164</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular access related</td>
<td>7 (11.1)</td>
<td>18 (11.1)</td>
<td>1.0</td>
</tr>
<tr>
<td>AV Block III°</td>
<td>2 (3.2)</td>
<td>8 (4.8)</td>
<td></td>
</tr>
<tr>
<td>DVT/Pulm. Embolism</td>
<td>0</td>
<td>2 (1.2)</td>
<td></td>
</tr>
<tr>
<td>GI Bleeding</td>
<td>1 (1.6)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Tamponade</td>
<td>1 (1.6)</td>
<td>1 (0.6)</td>
<td></td>
</tr>
<tr>
<td>Pneumonia/ARDS</td>
<td>2 (3.2)</td>
<td>1 (0.6)</td>
<td></td>
</tr>
<tr>
<td>Staph. aureus sepsis</td>
<td>0</td>
<td>1 (0.6)</td>
<td></td>
</tr>
<tr>
<td>LV electrode malfunction</td>
<td>0</td>
<td>1 (0.6)</td>
<td></td>
</tr>
<tr>
<td>CHF worsening</td>
<td>1 (1.6)</td>
<td>3 (1.8)</td>
<td></td>
</tr>
<tr>
<td>In-hospital death, n(%)</td>
<td>3 (4.8)</td>
<td>6 (3.7)</td>
<td>0.711</td>
</tr>
<tr>
<td>Cardiogenic shock</td>
<td>3 (4.8)</td>
<td>2 (1.2)</td>
<td></td>
</tr>
<tr>
<td>VT recurrence/shock</td>
<td>0</td>
<td>2 (1.2)</td>
<td></td>
</tr>
<tr>
<td>ARDS</td>
<td>1 (0.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV perforation/tamponade</td>
<td>1 (0.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend: DVT = deep venous thrombosis; GI Bleeding = gastro–intestinal bleeding; CHF = congestive heart failure; LV = left ventricle; ARDS = acute respiratory distress syndrome

Categorical data are presented as number and percentage; two–sided p value < 0.05 indicate significance. No difference in major complications rate and in–hospital mortality between NIDCM and ICM were observed.

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</th>
<th>ICM HR; 95% CI</th>
<th>P</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>1.3; 0.77 – 2.24</td>
<td>0.313</td>
<td>1.36; 1.02 – 1.81</td>
<td>0.034</td>
</tr>
<tr>
<td>Heart failure NYHA 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>Beta 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>

Legend: AAM = antiarrhythmic medication other than beta blocker

The table presents the multivariable analysis for the VT recurrence in NIDCM and ICM groups. The hazard ratios (HR) with the corresponding 95% confidence intervals (95% CI) and P values are presented. Procedure failure and partial success are independent predictors of VT recurrence in both NIDCM and ICM (2-sided p < 0.5). Additionally, the heart failure severity and the younger age are predictors of VT recurrence during the follow–up period.
Figure Legends:

**Figure 1.** Multivariable logistic regression for the predictors of acute complete success after RFCA of VT in NIDCM and ICM. ES = electrical storm; VT CL = ventricular tachycardia cycle length in milliseconds; \( \text{No VT} \) = number of VTs induced during the ablation; Epic abl. = additional epicardial ablation. The figure presents graphically the odds ratios (OR) for acute complete success with the corresponding 95% confidence intervals (95% CI), and p values. The epicardial ablation associates with beneficial acute outcome in NIDCM, while the number of inducible VTs is associated with worse acute outcome for every inducible VT.

**Figure 2.** Kaplan – Meyer curves for the VT - free survival after a single procedure for NIDCM and ICM after correction for the relevant confounders. The bold curve represents the cumulative VT free survival for the ICM and the dotted curve – cumulative VT free survival for the NIDCM. At the end of the first year (represented with a perpendicular dotted line) the VT free survival for ICM was 57% versus 40.5% for the NIDCM. At the end of the follow-up period (days), the cumulative VT free survival for the ICM was 43% versus only 23% in NIDCM. The hazard ratio for VT free survival was HR 1.73; CI 95% 1.029 – 2.905; p=0.039.
Figure 1

- **Age, y**
  - NIDCM: 1.02; 0.96 – 1.08, P = 0.598
  - ICM: 0.99; 0.95 – 1.04, P = 0.823

- **ES**
  - NIDCM: 1.98; 0.45 – 8.60, P = 0.364
  - ICM: 0.96; 0.40 – 2.30, P = 0.922

- **EF%,**
  - NIDCM: 1.00; 0.94 – 1.07, P = 0.904
  - ICM: 0.99; 0.95 – 1.03, P = 0.479

- **VTCL, ms**
  - NIDCM: 1.00; 0.99 – 1.01, P = 0.473
  - ICM: 1.00; 0.99 – 1.00, P = 0.660

- **No VT inducible**
  - NIDCM: 0.46; 0.26 – 0.82, P = 0.008
  - ICM: 0.61; 0.45 – 0.82, P = 0.001

- **Epic. Abl.**
  - NIDCM: 10.5; 2.52 – 44.0, P = 0.001
Figure 2

Cum VT Free Survival

<table>
<thead>
<tr>
<th>Days</th>
<th>ICM</th>
<th>NIDCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>164</td>
<td>63</td>
</tr>
<tr>
<td>200</td>
<td>93</td>
<td>33</td>
</tr>
<tr>
<td>400</td>
<td>66</td>
<td>21</td>
</tr>
<tr>
<td>600</td>
<td>53</td>
<td>10</td>
</tr>
<tr>
<td>800</td>
<td>34</td>
<td>4</td>
</tr>
<tr>
<td>1000</td>
<td>22</td>
<td>2</td>
</tr>
</tbody>
</table>

HR 1.73; CI 95% 1.029 - 2.905; p=0.039

57% (ICM)
40.5% (NIDCM)
43% 23%
Outcomes in Catheter Ablation of Ventricular Tachycardia in Dilated Non-Ischemic Cardiomyopathy in Comparison to Ischemic Cardiomyopathy: Results from the Prospective HEart Centre of LeiPzig VT (HELP - VT) Study
Borislav Dinov, Lukas Fiedler, Robert Schönbauer, Andreas Bollmann, Sascha Rolf, Christopher Piorkowski, Gerhard Hindricks and Arash Arya

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