Radiofrequency catheter ablation of ventricular tachycardia using combined endocardial techniques in patients with structural heart disease improves procedural effectiveness and reduces arrhythmia episodes

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ABSTRACT

Background: Evidence indicates that radiofrequency catheter ablation (RFCA) of ventricular tachycardia (VT) in patients with structural heart disease (SHD) is safe and effective. However, arrhythmia recurrence is still relatively high, and the optimal procedural strategy is unclear. In clinical practice, several combinations of mapping and ablation techniques are used to improve VT ablation efficacy.

Aim: The study aimed to evaluate and provide evidence on the efficiency and safety of a systematized combination of VT ablation (mapping) techniques in patients with SHD.

Methods: From 2016 to 2019, 47 patients (54 procedures) with SHD (89% heart failure, 94% ischemic heart disease, 37% VT storm) who underwent RFCA of VT were retrospectively analyzed from a group of 58 consecutive patients. During RFCA of VT, different combinations of three techniques, activation mapping (AM), pace mapping (PM), and substrate-based mapping (SbM), were used. The procedures were performed using the CARTO® 3 (Biosense Webster Inc., Diamond Bar, CA, US) electro-anatomical mapping system.

Results: During a median (interquartile range [IQR]) follow-up of 25.5 months (11.75–52.25), VT-free survival after ablation was 68.5% (n = 37/54 procedures). Acute procedural success was achieved in 85% (n = 46/54 procedures). The number of induced VT morphologies, induction of non-clinical or non-sustained VT after ablation, and fewer VT mapping techniques used during the procedure were related to decreasing VT-free survival.

Conclusions: VT ablation strategy based on systemic use of combined techniques is effective and safe in long-term follow-up of patients with SHD.

Key words: catheter ablation, heart failure, pace mapping, ventricular tachycardia

WHAT'S NEW?

A combination of multiple mapping techniques, two or three, improves procedural efficacy and reduces cardioverter-defibrillator interventions. A systematized ventricular tachycardia ablation procedure based on using the techniques in a certain sequence is comparable to the efficacy of the endo-epicardial approach.

INTRODUCTION

Modern treatment of ischemic heart disease and heart failure has significantly reduced patient mortality, while the number of patients who required treatment for ventricular tachycardia (VT) has increased. Monomorphic VT is mainly associated with a co-existing arrhythmia substrate, such as scarring (post-infarction) or fibrosis. Episodes of ventricular tachycardia can significantly worsen a patient's quality of life (QoL) and increase mortality [1, 2]. Treatment of VT is based on pharmacotherapy and radiofrequency catheter ablation (RFCA). RFCA is the most effective method of VT treatment, which reduces the number of implantable cardioverter-defibrillator (ICD) high-energy shocks and improves QoL and patient outcomes after a VT storm [3–6].

Fundamentally, three techniques of VT mapping are used in clinical practice. The first is activation and entrainment mapping, the second is substrate-based mapping (SbM), and the third is pace mapping (PM). Activation/entrainment mapping (AM) defines the VT mechanism and localization of the arrhythmia circuit with critical isthmus. Although AM is a very desirable mapping technique, it requires sustained VT with hemodynamic tolerance.

The second technique, SbM, is an effective complement to AM aimed to eliminate VT substrate represented by abnormal ECGs in the low-voltage areas. Three-dimensional (3D) electro-anatomical mapping systems define low-voltage areas (scar and fibrotic regions) and facilitate identification and ablation of the arrhythmia substrate. Effective SbM compared to AM, decreases the recurrence rate of VT and is optimal for use in unmappable VT.

The third commonly used method in VT ablations is ventricular PM. This method is beneficial in focal VT and has the potential to assist in identifying critical areas of VT re-entry [7].

In patients with structural heart disease (SHD), all RF ablation methods can be used separately or may be combined in various configurations to eliminate VT. The selected technique depends on the patient's condition and arrhythmia complexity.

Aim

This retrospective analysis concentrated on the safety and efficiency of using a combination of VT mapping techniques in patients with structural heart disease (SHD) in long-term follow-up.

METHODS

Records of 58 consecutive patients with SHD undergoing a VT ablation procedure between January 2016 and November 2019 were used for analysis. Forty-seven patients with 54 RFCA (7 repeat procedures) were retrospectively evaluated. Eleven of the patients who did not fulfill eligibility criteria (lost to follow-up, no records of final arrhythmia inducibility, lack of sufficient electrophysiological data from the procedure) were excluded from the study.

According to the European Society of Cardiology guidelines, patients were referred for RFCA immediately after VT occurred or was noted on ICD recordings [8, 9]. The procedures were performed using an electrophysiological system (Bard Labsystem Pro 2.4) and the CARTO® 3 (Biosense Webster Inc., Diamond Bar, CA, US) electro-anatomical mapping system.

Transthoracic echocardiography was used to assess the size and location of previous myocardial damage. Coronary angiography was performed on all patients before radiofrequency ablation to exclude an ischemic cause of sustained ventricular arrhythmia (except 1 patient). All RFCA procedures were performed under conscious sedation achieved with midazolam and fentanyl, as necessary. Ablations were performed by skilled operators (>150 ablations/year) experienced with VT ablation techniques.

Left ventricular access was either transaortic, transseptal, or both. Intravenous heparin was administered to maintain an activated clotting time of 250–350 seconds. The 3D geometry of the ascending aorta (in transaortic access) and the left ventricle was reconstructed with a fast anatomical map with voltage map (bipolar map setting: from 0.5 mV to 1.5 mV) performed by an ablation catheter with automatic annotation by CARTO® Confidence module. The workflow sequence started from substrate-based mapping, then pace mapping, and if possible, activation mapping. Below, all subsequent phases are described.

The substrate-based mapping was performed during sinus rhythm in patients with rhythm over 50 bpm or RV pacing in stimulation-dependent patients. The map collection contained at least 500 points.

During mapping of the left ventricle, local abnormal ventricular activities (LAVA) and late potentials (LP) were identified and marked. The area of dense scar (<0.5 mv) was confirmed and depicted by the lack of stimulation (20 mA/1 ms). Subsequently, programmed ventricular

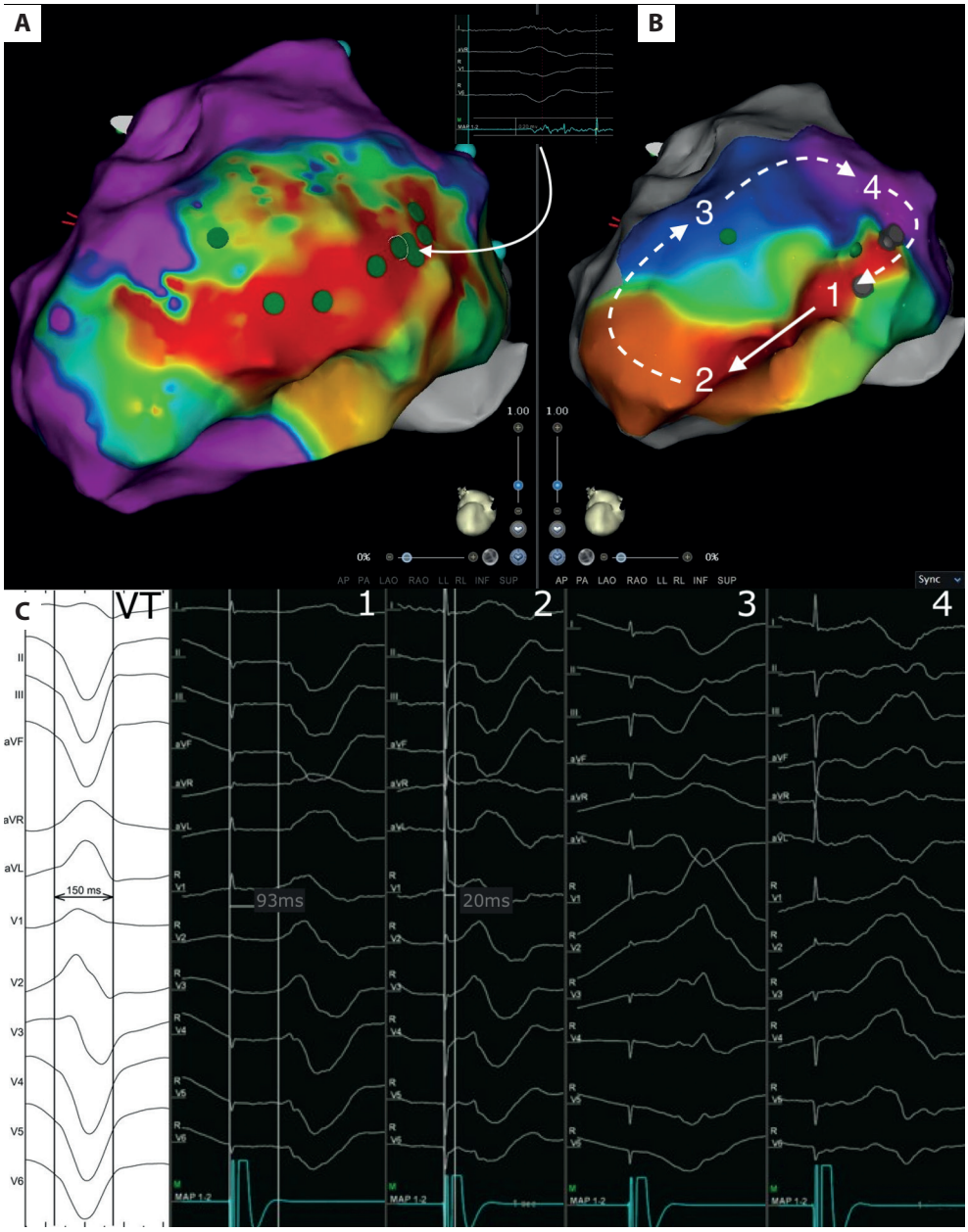

Figure 1. A–C. Substrate-based mapping and pace mapping combination. **A.** Voltage map (0.2– 1.5 mV) of the left ventricle shows low voltage area extending from the MV (blue dots) to the apex with LPs (green dots) marked in the central part of the scar (<0.2 mV). Panel **B.** shows reconstruction of the VT circuit performed by pace mapping (color-coded, same as activation mapping). In panel **C.** pacing from a different position is shown. Pacing site no 1 is located inside the condition channel — paced QRS morphology compliance with clinical VT is more than 85% with long S-QRS (93 ms). Pacing site no. 2 is of VT exit site with good QRS compliance and short stimulus-QRS (20ms). No. 3 area with border QRS compliance (85%–30%) with clinical VT shows an outer loop and no. 4 with low QRS compliance (<30%) is entrance site of the VT circuit

Abbreviations: LPs, late potentials; MV, mitral valve; VT, ventricular tachycardia

stimulation (PVS) from the right ventricle (RV) was performed at drive train 500 ms with up to 3 extra stimuli decremented to ventricular refractoriness (>200 ms) or VT induction. If no VT was induced from the RV, the stimulation program was repeated from the left ventricle. After VT induction, the QRS pattern in VT was collected, and arrhythmia was interrupted. Next, the VT exit site was predefined by pace mapping (defined as QRS morphology compliance with clinical VT of more than 85%), after which the entrance site was determined (defined as an abrupt shift in QRS morphology to ≤30% of the clinical VT). During PM, a delay of post-pacing stimulation interval stimulus-QRS (S-QRS) was marked and measured (Figures 1, 2). If two methods were used (PM plus SbM), this approach was named a "dual technique".

For hemodynamically tolerable VTs, activation mapping was also performed, and this technique was named "triple". Finally, after using all presented techniques, the area of interest was determined. Entrainment mapping was performed at pre-defined points of interest, in the case of VT hemodynamical tolerance, followed by RF application (VT maintenance as short as possible). RFCA was performed in the area of interest predefined by all applied techniques. During mappable VT (triple mapping technique), activation and entrainment mapping of the critical isthmus was an initial target, followed by LAVA's elimination in the predefined area. The dual mapping technique procedures aimed to target and eliminate LAVAs from the predefined area, as demonstrated by no pacing capture from the ablated region.

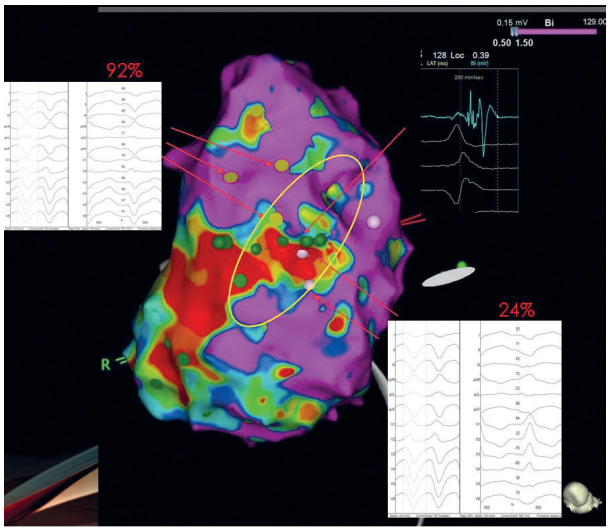

Figure 2. Substrate-based mapping and pace mapping techniques. Voltage map (0.5–1.5 mV) of the left ventricle during sinus rhythm with marked LPs (green dots) (CARTO, Biosense Webster Inc., Diamond Bar, CA, US). VT pace mapping limited to locating the VT exit site (yellow dots) (PM, 92% compatibility to clinical VT) and VT entrance site (white dots) (abrupt transition in clinical VT compatibility, 24%). Primary targeted area for ablation based on PM and mapping of regional LPs, marked by the yellow circuit

Abbreviations: see Figure 1

Finally, PVS from the right and left ventricles was performed for RFCA efficacy assessment in all cases. When non-inducibility of any sustained VT occurred, the procedure was considered effective (acute success).

Follow-up

During the follow-up period, the patients were monitored in the outpatient center with device interrogation (minimum twice per year) or remained under telemonitoring control (CareLink™, Medtronic; Home Monitoring, Biotronik). Any VT recurrence with an adequate ICD intervention (anti-tachycardia pacing or delivery of a high-energy shock) during the follow-up period was evaluated and considered as an ablation failure. Repeat ablation, if necessary, was considered with an endo- or epicardial approach. The endocardial procedures were performed in the same electrophysiology lab while the epicardial approach was transferred to a tertiary electrophysiology center and excluded from analysis. The minimum follow-up was 12 months.

Ethical statement

The study was approved by an appropriate institutional review board (L.dz.OIL/KBL/7/2021). Approval of the bioethics committee was not obligatory due to the retrospective nature of the study.

Statistical analyses

Data were presented as numbers and percentages for categorical variables with means and standard deviations (SDs) for normally distributed continuous variables or medians and interquartile ranges for continuous variables with nonnormal distribution. The normality of data distribution was verified by the Kolmogorov-Smirnov test. Categorical variables were analyzed using the chi-squared test or Fisher's exact test.

The graphic presentation of long-term VT-free survival was shown using Kaplan-Meier curves. The Andersen-Gill model for recurrent event times (simple extension of the Cox model) was used to test the effects of clinically significant predictors of VT recurrence. Survival curves were compared with the log-rank test. All pooled estimates were displayed with a 95% confidence interval [CI]. The non-parametric Mann-Whitney U test for independent samples was used to compare the period between the single (first-time) and repeat procedure.

All statistical tests were 2-tailed, and a P <0.05 was considered statistically significant. All the analyses were performed in IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, US) and statistical package R, Version 4.2.1 (http://r-project.org).

RESULTS

Study group characteristics

We retrospectively analyzed 54 RF ablation procedures (7 repeat ablations) of VT. Almost all included patients (n = 47) with SHD had systolic heart failure (89%; n = 43) and ischemic heart disease with previous myocardial infarction (94%; n = 44). Three patients from the selected group had dilated cardiomyopathy. All the patients underwent ICD implantation for primary or secondary prevention before ablation.

From the 54 included ablation cases, 87% (n=47) were single (first-time) ablations, and 13 % (n = 7) were repeat ablations. VT storm as an indication for the ablation procedure was observed in 37% (n = 20) of all cases while 63% (n = 34) were due to detection of repeated sustained VT (terminated with ICD shocks or anti-tachycardia pacing [ATP]) in the implanted device's memory.

In the single (first-time) ablation group (n = 47), VT storm was noticed in 24% (n = 13), while in the repeat ablation group, VT storm was the only indication (100%; n = 7) (Table 1).

Procedural characteristics and acute success

Access to the left ventricle was obtained mainly via the transaortic route in 80% (n = 43) of patients while the transseptal approach was used in 20% (n = 11). Median (interquartile range [IQR]) procedural and fluoroscopy times reached 182.0 min (140.0–211.0) and 7.6 min (3.0–10.7), respectively. During the ablation procedure, 1 to 5 different VT morphologies were induced. Single VT morphology was induced in 48.1% (n = 26), two VT morphologies in 18.5% (n = 10), three morphologies in 22.2% (n = 12), and four or more in 11.2% (n = 6). A dual mapping/ablation strategy (SbM plus PM) was used in 64.8% (n = 35), and the triple

Table 1. Baseline patient characteristics (n = 47)

Baseline characteristic	Value
Age, years, median (IQR)	64.5 (60.7–69.5)
Male sex, n (%)	45 (95.7)
Hypertension, n (%)	35 (74.5)
Diabetes mellitus/IFG, n (%)	16 (34.0)
Obesity with BMI >30 kg/m^2, n (%)	20 (42.5)
Nicotinism, n (%)	
Former smokers	36 (76.6)
Active smokers	6 (12.8)
Heart failure, n (%)	42 (89.4)
Significant renal failure, eGFR <40 ml/min/1.73 m^2, n (%)	4 (8.5)
NYHA class, n (%)	
I	5 (10.6)
II	25 (53.2)
III	11 (23.4)
IV	1 (2.1)
Ischemic heart disease, n (%)	44 (93.6)
Dilated cardiomyopathy, n (%)	3 (6.4)
Left ventricular ejection fraction, %, median (IQR)	30.0 (20.0–40.0)
Dyslipidemia, n (%)	31 (66.0)
Atrial fibrillation, n (%)	17 (36.2)
Thyroid insufficiency and hyperthyroidism in medical history, n (%)	9 (19.1)
Hyperthyroidism	4 (8.5)
Hypothyroidism	5 (10.6)

Abbreviations: BMI, body mass index; IFG, impaired fasting glucose; NYHA, New York Heart Association; VT, ventricular tachycardia

Table 2. Procedural characteristics

	Overall 54 procedures (100)
LV access, n (%)	Transaortic: 43 (79.6) Transseptal: 11 (20.4)
No. of VT morphologies induced during ablation, n (%) for all patients	
One	26 (48.1)
Two	10 (18.5)
Three	12 (22.2)
Four or more	6 (11.2)
No. of VT morphologies induced during ablation, n (%) in the DCM subgroup	
One	2 (Non-BBBR VT)
Two	1 (Non-BBBR VT)
Procedural time, min, median (IQR)	182 (140.0–211.0)
Fluoroscopy time, min, median (IQR)	7.6 (3.0–10.7)
PVS after ablation, n (%)	
Clinical VT	0 (0.0)
NsVT	9 (16.7)
Nonclinical VT	8 (14.8)
Dual mapping/ablation technique (PM+SbM), n (%)	35 (64.8)
Triple mapping/ablation technique (PM+SbM+AM), n (%)	19 (35.2)
Redo ablation, n (%)	7 (13.0)
VT Storm, n (%)	20 (37.0)

Abbreviations: AM, activation mapping; LV, left ventricular; PM, pace mapping; Non-BBBR VT, non-bundle branch block reentry ventricular tachycardia; nsVT, non-sustained ventricular tachycardia; PVS, programmed ventricular stimulation; SbM, substrate-based mapping; TA, transaortic; TS, transseptal; VT, ventricular tachycardia

mapping technique (AM plus SbM plus PM) was possible in 35% (n = 19) of cases.

The acute procedural success rate was 85% (n = 46). All induced and sustained VT were non-clinical (15%, n = 8). Additionally, in 16.6% (n = 9) of procedures, non-sustained VT with spontaneous termination was induced. None of the patients had VF during the final PVS. Detailed characteristics are listed in Table 2.

Long-term ablation success

After three months of blanking period after the ablation procedure, a median (IQR) follow-up of 25.5 (11.75–52.25) months, overall VT-free survival rate reached 68.5% (n = 37). After a repeat procedure, VT-free survival was not significantly higher than after single (first-time) ablation (71% vs. 68.5 %; $P = 0.37$) (Figure 3). Median (IQR) time of observation after the repeat procedure was 18.0 (3.0–26.0) months. Median (IQR) time for VT recurrence afterthe first-time procedure was 6.4 (2.2–11.6) months, so this period was considered sufficient, even though the observational period between the single (first-time) and repeat procedure was significantly different ($P = 0.024$).

A recurrence of VT was considered an unsuccessful procedure. Seventeen patients during the observation time experienced ICD intervention (ATP or/and shock) due to VT. Fifteen of them (88%) had VT recurrence after the primary procedure, and two (12%) after the repeat procedure.

In the group of patients with a VT recurrence after a single procedure (n = 15), a repeat procedure was recommended due to VT storm in ten cases (67%). Seven of them were qualified for endocardial RFCA in our electrophysiology (EP) center (repeat ablation group n = 7), and three others were referred for epicardial ablation in a different EP lab. The remaining patients (n = 5) were under clinical observation and did not accept repeat ablation due to asymptomatic, rare arrhythmia episodes terminated by ATP.

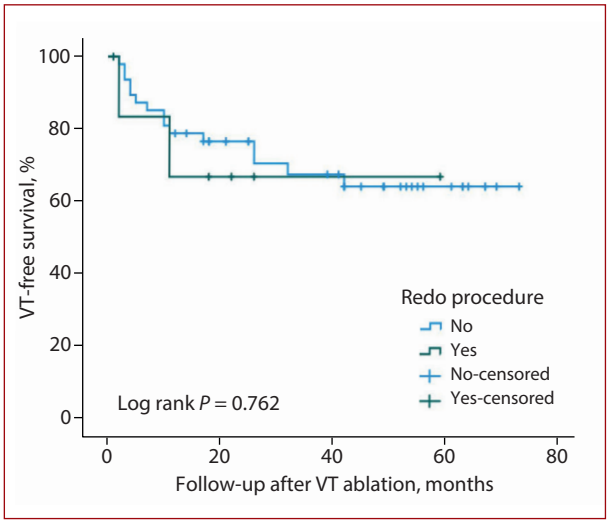

Figure 3. Kaplan-Meier curves of the long-term ablation success (VT-free) according to the ablation procedure (single vs. repeat ablation)

Abbreviations: see Figure 1

Table 3. Predictors of time to VT recurrence in univariate Cox regression analysis in the matched groups (n = 54)

	Univariate analysis	
	HR (NA) (95% CI)	*P*-value
Age	0.89 (0.76–1.04)	0.144
HT	3.80 (0.64–22.72)	0.142
Dyslipidemia	1.54 (0.42–5.69)	0.518
NYHA class	1.71 (0.57–5.19)	0.340
HF >II	2.17 (0.62–8.23)	0.426
DM	7.69 (1.39–43.48)	0.020
AF	1.09 (0.26–4.50)	0.905
LVEF	1.04 (0.95–1.14)	0.340
VT storm	1.24 (0.36–4.32)	0.731
Ablation technique[a]	5.11 (1.07–24.43)	0.041
Number of VTs morphologies induced	2.36 (1.20–4.61)	0.012
Induction of any- VT in final PVS	1.17 (0.73–1.89)	0.532
Amiodaron	0.33 (0.09–1.16)	0.084

[a]Triple technique vs dual technique (triple references)

Abbreviations: AF, atrial fibrillation; CI, confidence interval; DM, diabetes mellitus; HF, heart failure; HR (NA), non-adjusted hazard ratio; HT, hypertension; LVEF, left ventricular ejection fraction; PVS, programmed ventricular stimulation; VT, ventricular tachycardia

Importantly, after both single and repeat ablations in our study group, the VT storm burden was dramatically reduced (none of the patients after repeat ablation). One patient with VT during follow-up had successful heart transplantation due to heart failure progression. Comparing the patient's clinical characteristics, we found that type 2 diabetes mellitus (T2DM) was related to an increased VT recurrence rate. Numbers of induced VT had similar impacts during ablation or lack of the triple mapping technique combination (AM plus SbM plus PM) (Table 3, Figure 4).

In the final ablation, PVS, independent from procedural technique combination, induction of non-sustained VT (n = 9; 16.7%) or non-clinical VT (n = 8; 14.8%) was not related to a higher recurrence rate in long-term follow-up (*P* = 0.5).

In patients with dilated cardiomiopathy (DCM) (three patients) — the acute procedural success rate was 100%. The number of VT induced during the ablation procedure was two different morphologies in one patient and one morphology in two patients. None of induced VT were bundle branch block reentry. A dual mapping/ablation strategy (SbM plus PM) was used in two DCM patients, and a triple mapping technique (AM plus SbM plus PM) was done in one case. The long-term success rate reached 66% (2 of 3).

Amiodaron was continued after ablation in 41% (n = 22) cases throughout the three months during the blanking period. Detailed univariate analysis with hazard ratios in long-term follow-up is presented in Table 3.

Complications

During the periprocedural period, there were 4 (7.4%) complications. Two groin hematomas not requiring intervention, one stroke (transaortic approach), one episode of pulmonary edema deteriorating to cardiac arrest (pulseless

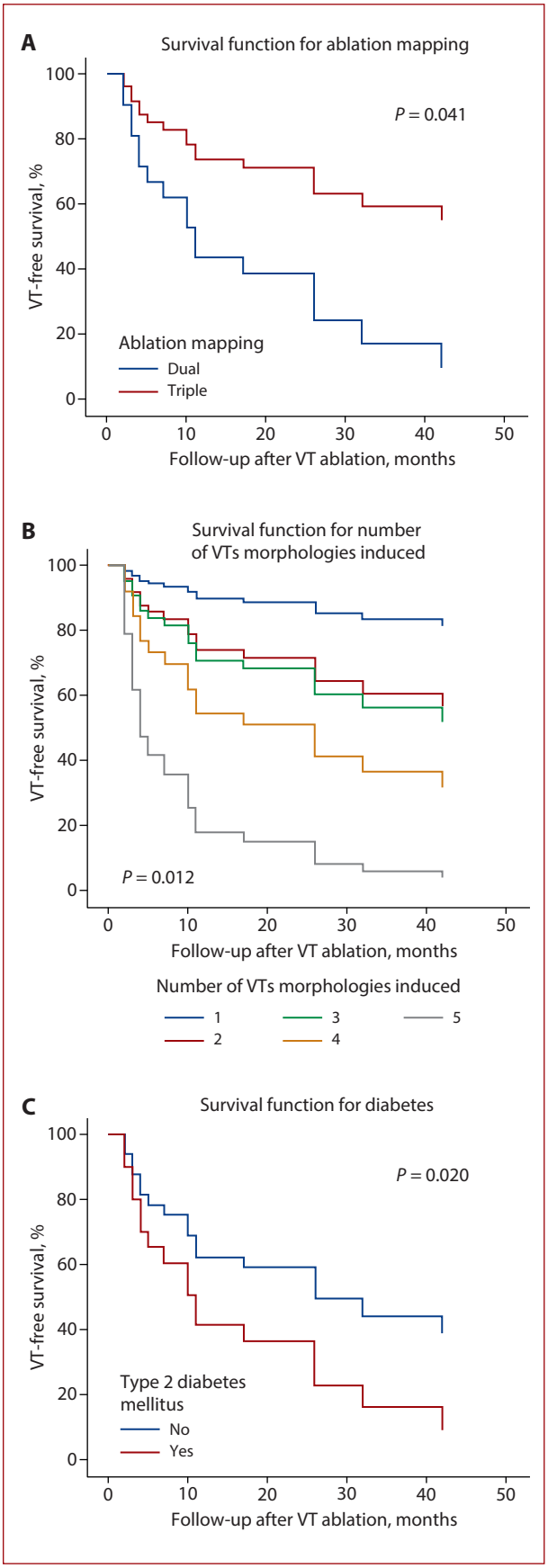

Figure 4. A. VT-free survival curves depending on ablation mapping technique (dual vs. triple). **B.** Number of VT morphologies during ablation. **C.** Type 2 diabetes mellitus

Abbreviations: see Figure 1

electrical activity), and patient death. In postprocedural observation, two patients died in the first year of follow-up due to progression of heart failure.

DISCUSSION

According to evidence, RFCA of VT in patients with SHD is safe and effective [10]. However, arrhythmia recurrence is still relatively high, and the optimal procedural strategy is unclear [11]. Our study aimed to evaluate VT ablation (mapping) techniques in patients with SHD and provide evidence on the efficiency and safety of using them in a systematized combination. Starting from the substrate-based mapping followed by pace mapping, and ending with activation mapping (if possible), may be a useful strategy to enhance the success of VT ablation procedures.

Substrate-based ablation concerns more widely fibrotic areas (scar) and conduction channels represented by fragmented/late potentials (Figure 4). Total elimination of LAVAs/LPs seems to be an optimal endpoint of substrate-based ablation but is difficult to achieve [12–15]. In the study by Wolf et al., total substrate elimination was successful in only 64 %, with a VT-free survival rate of 73% after one year [13]. In a recent prospective and randomized multicenter study (Berlin VT), RF ablation was performed within the entire area of late potentials. Total LP elimination was achieved more frequently than non-inducible VT. During the 24-month follow-up, the recurrence of ventricular tachyarrhythmia reached 39.7% in the preventive and 48.2% in deferred ablation strategies [16]. In the present study, total substrate elimination (LAVAs/LP) was not the main, but an optional target of ablation. Substrate-based ablation was mainly limited to the myocardium area related to induced clinical or non-clinical VT.

Pace mapping has also been featured as a technique to identify the critical VT isthmus [7, 17]. Demonstrating high compliance of the paced QRS complex in clinical VT with a short S-QRS interval is typical of VT exit (Figure 3). Pacing with a prolonged S-QRS interval and high compliance to VT demonstrates a potential critical isthmus. Once pacing shows an abrupt transition to unmatched QRS morphology, this indicates the entrance of clinical VT [7]. This technique helps to identify the critical VT isthmus without performing activation mapping but may not recognize the multiple circuit branches with other VT morphologies [17]. Our study identified the primary ablation target by pace mapping related to abnormal regional electrograms elucidated by initial substrate mapping. This specified "area of interest" was the perfect zone for activation and entrainment mapping (if possible).

Unfortunately, the long-term effectiveness of VT pace mapping as a single mapping strategy is not known in publications. Combinations of PM and SbM were the most common RFCA strategy in our study (64.8%).

The final step of the workflow was activation mapping and especially entrainment mapping. This technique is performed to confirm the VT critical isthmus site and completes VT mapping [18]. However, activation mapping and entrainment are not possible in every procedure. Prolonged, sustained VT during the mapping process may increase the risk of periprocedural hemodynamic collapse and may not be applicable [19]. Otherwise, VT inducibility and stability are difficult to sustain. Additionally, it has been shown that this single technique is not always sufficient in defining the optimal site for RFCA [20]. According to the literature, RFCA based only on activation/entrainment mapping had a relatively high (48%) risk of arrhythmia recurrence in a 12-month follow-up. Compared to substrate-based ablation, it had inferior outcomes [21]. Our strategy did not force the third step — AM (35.2% of cases) and was reserved for insistent or slow VTs with relatively low periprocedural hemodynamic decompensation. Once the three steps were achieved, the VT mapping was optimal. The results validate this strategy. The long-term follow-up of 24 months without VT reoccurrence reached 85% after three mapping methods were used and 64% without activation mapping ($P = 0.041$). However, as we emphasize in the limitation section, due to the small number of patients, the results should be interpreted with caution.

Repetitive non-inducibility of VT after ablation was an acceptable endpoint in our study. We showed that the induction of non-clinical VT or non-sustained VT at the end of the procedure increases the risk of arrhythmia recurrence in long-term observation, which has also been demonstrated in a previous publication [22].

Apart from the ablation strategy, a primary VT burden significantly impacted the results. Although VT storm was not related to an increased VT recurrence rate, the number of induced VTs during the procedure had the highest impact on long-term success ($P = 0.012$). Our results concur with other publications [23]. Nevertheless, during the follow-up period after repeat ablations, the VT storm burden was reduced considerably compared to the single VT RFCA, which seems to be important for patient QoL [24].

Our results of long-term VT-free survival (overall 68.5%) comply with available results and also with epicardial techniques used [13, 14, 21, 25]. The balance between optimal procedural outcomes with procedural complexity and aggression (total LP abolition, epicardial approach) needs to be further studied. Also, in further investigation, the role of diabetes should be further analyzed. In the urinative model, T2DM had the highest risk of VT recurrence ($P = 0.20$; HR, 7.69). The recent colossal impact of SGLT2 inhibitors on HF treatment and reduction of arrhythmic burden may reflect this outcome [26, 27].

Our study shows that VT ablation based on a systematized combination of techniques (performed step by step), with all their benefits and limitations, was safe and effective in patients with SHD in long-term follow-up.

Study limitations

The study had a relatively small sample size and was conducted in a single-center set-up. Retrospective and non-randomized features of the study also decreased its

final impact. A small number of patients requires cautious interpretation of the results. Despite these limitations, we believe that these limitations did not undermine the results.

CONCLUSIONS

Our study shows that the VT mapping and ablation procedure based on combined and systematized techniques performed in a predefined sequence, with all their benefits and limitations, was safe and effective in patients with SHD in long-term follow-up.

Article information

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