Catheter ablation of repetitive ventricular tachycardia in patients with ischemic heart disease – our experience

Katetrska ablacija ponavljajoče se prekatne tahikardije pri bolnikih z ishemično boleznijo srca – naše izkušnje

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Abstract

Background: Ventricular tachycardia (VT) poses a significant risk for sudden death and heart failure exacerbation in patients with ischemic heart disease. Catheter-based radiofrequency ablation is the last treatment option for patients with frequent VT recurrences despite antiarrhythmic drugs. The aim was to present our retrospective catheter ablation data in this group of patients.

Patients and methods: The majority of 34 patients, who underwent percutaneous endocardial radiofrequency catheter ablation, were male, median age 67.5 years, who presented with electrical storm, had underlying cardiomyopathy after remote inferior wall myocardial infarction and preceding myocardial revascularization procedure, and had been implanted with cardioverter-defibrillator (ICD). Two ablation methods were used: linear ablation and/or scar homogenization. Acute ablation success (non-inducibility of any VT) was achieved in 59 % of procedures. VT could not be interrupted in 2 (6 %) patients. Pericardial tamponade that needed surgical intervention occurred in one procedure (2 %), and was related to inadvertent perforation of the right ventricular apex with a diagnostic catheter. Seven (20 %) patients died and additional 3 were lost from the median of 31 (6–151, rank) months of follow-up. No late VT recurrences were demonstrated in 20 (59 %) patients, and rare in 4 (12 %). Overall, the ablation procedure was successful in 71 % of patients.

Conclusion: Catheter ablation gave very good long-term clinical result in about two-thirds of our patients with ischaemic cardiomyopathy and frequent VT recurrences. Catheter ablation, preferably with scar homogenization approach, should be considered early to reduce the number of VT episodes and ICD discharges.

Izvleček

Izhodišča: Pri bolnikih z ishemično boleznijo srca je prekatna tahikardija (VT) pomemben dejavnik tveganja za nenadno smrt ali poslabšanje srčnega popuščanja. Katetrska radiofrekvenčna ablacija je zadnja možnost za bolnike s pogostimi napadi VT, pri katerih zdravljenje z antiaritmiki ni učinkovito. Namen prispevka je predstaviti naše retrospektivne rezultate katetrske ablacije VT pri teh bolnikih.

Pacienti in metode: Večina od 34 bolnikov, pri katerih smo opravili perkutano endokardno radiofrekvenčno katetrsko ablacijo, so bili moški mediane starosti 67,5 let, ki so imeli ob sprejemu električni vihar in kardiomiopatijo po starem spodnjestenskem srčnem infarktu. Večina je že imela opravljen revaskularizaciski poseg in vsajen kardioverter defibrilator (ICD). Ablacijo smo opravili na dva načina – z linijskimi ablacijami in/ali s homogenizacijo brazgotine. Akutni ablacijski uspeh (neizzivnost katere koli VT) smo dosegli pri 59 % posegov. Pri 2 (6 %) bolnikih nam z ablacijo ni uspelo prekiniti VT. Tamponada, ki je zahtevala kirurško intervencijo, je nastala pri enem posegu (2 %) in je bila pov-

zročena z diagnostičnim katetrom v desnem ventriklu. V 31 (6–151) mesecih spremljanja (mediana in rang) je umrlo 7 bolnikov (20 %) in 3 (9 %) se niso več oglasili v ambulanti. Pri 20 (59 %) bolnikih nismo beležili poznih recidivov VT, pri 4 (12 %) pa redke. Ablacijski poseg je bil torej uspešen pri 71 % naših bolnikov.

Zaključki: Pri dveh tretjinah naših bolnikov z ishemično kardiomiopatijo in pogostimi napadi VT smo dosegli s katetrsko ablacijo zelo dober dolgoročen klinični rezultat. Zato s posegom ne smemo odlašati, saj le na tak način lahko učinkovito preprečimo ponovne napade VT in proženje ICD. Prednost ima metoda homogenizacije brazgotine.

1. Introduction

Ventricular tachyarrhythmias (VA) pose a significant risk for sudden death and heart failure exacerbation in patients with ischemic heart disease (IHD). One-third of deaths after myocardial infarction (MI) is caused by VA. Survival of these patients improved considerably after introduction of implantable cardioverter-defibrillators (ICDs) (1). However, ICD shocks are painful, cause anxiety, depression, and more visits to emergency department–all resulting in a low quality of life. Almost one-fourth of patients experienced an ICD discharge after 5 years of follow-up in the ALTITUDE registry. In addition, frequent ICD discharges may in itself increase mortality (2). Beta-blocking drugs and amiodarone reduced the incidence of ventricular tachycardia (VT) in some patients, however amiodarone is toxic and was withdrawn in almost one-quarter of patients (3).

Catheter-based radiofrequency (RF) ablation is currently treatment of choice for patients with structural heart disease and frequent VT (4,5). In addition, the new generation of 3-D electro-anatomical mapping systems have substantially improved ablation results (5,6). These systems enable accurate heart chamber anatomical reconstruction, reproducible delineation of normal myocardium from the scar, based on electrogram amplitude, accurate determination of VT activation sequence, as well as reliable navigation and positioning of ablation/mapping and diagnostic catheters, reducing the need for fluoroscopy (Figure 1). With successful ablation procedure there are less ICD discharges, less hospitalizations, better quality of life, and possibly improved survival (6,7).

The aim was to present our retrospective catheter VT ablation results in patients with IHD.

2. Patients and methods

From a cohort of patients treated at our institution from January 2000 to December 2014 for recurrent symptomatic VA or frequent ICD shocks despite amiodarone and beta-blocking drug treatment, patients with IHD were selected in whom a catheter RF ablation procedure was performed. In addition to left ventricular thrombus, acute triggers for VA, such as ischemia, heart failure not caused by VT, infection, electrolyte or acid-base imbalance, and stroke, had to be excluded before the procedure. Therefore, coronary angiogram and echocardiogram were performed in all. The SPECT scan, gadolinium-enhanced MR scan, and CT were performed if feasible. A 12-lead ECG of clinical VT was acquired if available. All patients or relatives provided an informed consent before the procedure.

Ablation procedure was usually performed in the conscious-sedated pati-

Table 1: Clinical characteristics and catheter ablation results in our patients with ischemic heart disease and recurrent ventricular tachycardia.

Patients (n)	34
Age (median, range)	67.5 years (53–84)
Men (n)	31 (91 %)
Electrical storm*	23 (68 %)
Slow VT**	16 (47 %)
MI in the past	30 (88 %)
-infero-posterolateral scar	24 (80 %)
LVEF < 45 %	27 (79 %)
ICD	23 (68 %)
Myocardial revascularization in the past	25 (73 %)
Arterial hypertension	23 (68 %)
Chronic kidney disease II-IV***	8 (24 %)
Atrial fibrillation/flutter	7 (21 %)
Peripheral vascular disease	5 (15 %)
Diabetes (n)	4 (12 %)
Ablation procedure results (n)	44
- success	19 (59 %)
- partial success	8 (25 %)
- failure	5 (16 %)
- not tested	12 (28 %)
DAP (µGym^2) median (range)	667 (155–5182)
Fluoroscopy (min) x ± SD (range)	21 ± 14 (8–68)
Procedure time**** (min) x ± SD (range)	240 ± 52 (165–345)
Tamponade	1 (2 %)
Follow-up results (median, range)	31 months (6–151)
- no VT recurrence	20 (59 %)
- rare late VT recurrences	4 (12 %)
- death up-to 6 months	5 and 1$^+$
- all deaths	7 and 3$^+$

**≥ 3 separate episodes of ventricular tachyarrhythmia in 24 h, each requiring termination by ICD or other intervention; ** ≤ 140/min; ***glomerular filtration rate: 15–89 mL/min/1.73 m^2; ****from punction to catheter withdrawal;$^+$ absent after the last regular ICD visit; MI – myocardial infarction, LVEF – left ventricular ejection fraction, ICD – implantable cardioverter defibrillator, DAP – dose area product, AAD – antiarrhythmic drugs*

ents (fentanyl, midazolam or propofol), anticoagulated with unfractionated heparin – activated coagulation time 300–400 s –, and with invasively monitored arterial pressure. The 3-D electro-anatomical mapping system (CARTO, Biosense-Webster), irrigated-tip RF ablation catheter–with retrograde or trans-septal approach – and fixed or steerable long sheaths were used. The ablation strategy evolved over time. At the beginning, a »*linear ablation*« approach was used. Linear lesions were performed between the low-voltage areas and to the mitral annulus, or around and across low-voltage areas, particularly near the VT exit sites. Later on, a »*scar homogenization or scar de-channelling*« approach was implemented (Figure 1). A dense voltage--mapping during sinus rhythm for substrate characterization was performed and RF ablation of all local electrograms (EGs) within the low-voltage area, which characterize a viable myocardium within the scar, was done. The VT induction attempt with programmed stimulation was performed only at the end of the procedure to assess the treatment result. Low-voltage area was defined for EGs less than 1.5 mV. The pace-mapping was performed at low-voltage areas to define VT exit sites and conducting channels according to QRS morphology and stimulus-to-QRS time. Sustained or non-sustained clinical VT is frequently induced at this point. The entrainment mapping was quickly done to define slow-conducting zone in patients with haemodynamically stable VT. RF applications (35–50W, 17–30 mL/min) were targeting all sharp fragmented EGs at sites with long pace-to-QRS time (> 50 ms) or diastolic EGs during VT. The ablation endpoint was disappearance of all local EGs in the low-voltage area with loss of capture at 10 mA, 2 ms, providing a good catheter-tissue contact (8). The

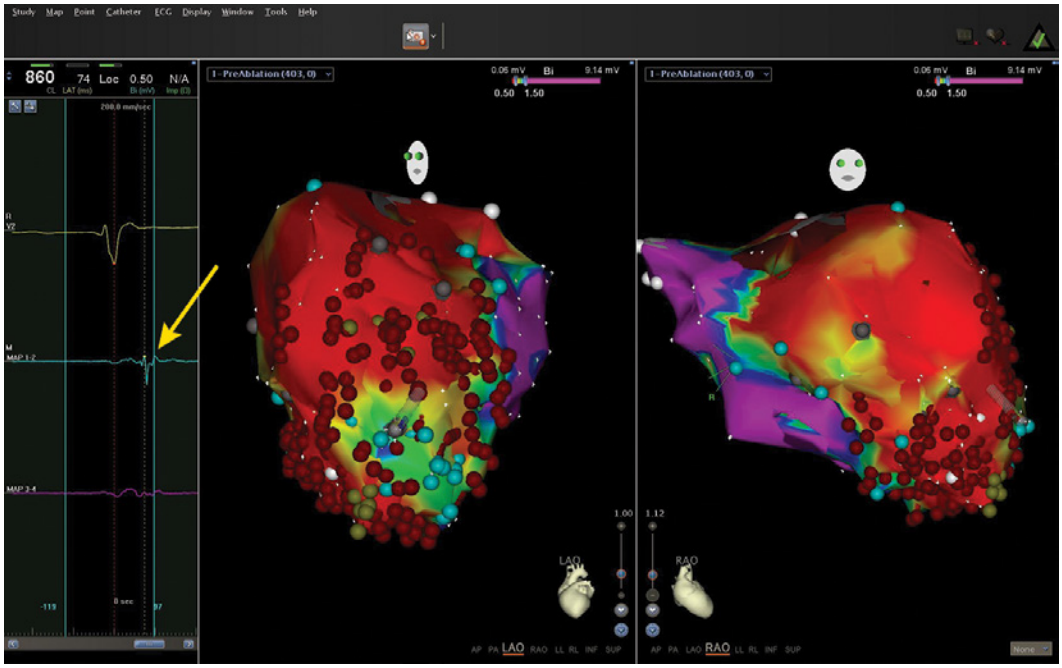

Figure 1: The »scar homogenization« or »scar de-channelling« ablation approach. Radiofrequency catheter ablation lesions are tagged with dark red points on the red background of the low-voltage area. Normal-voltage area is shown in purple. This approach seems more successful than former linear ablation approach. A sharp late local electrogram – an ablation target–is marked by an arrow. It represents muscle tissue within the scar that is activated late, after the QRS complex seen above.

final step was programmed stimulation from the right ventricle and from the border of the ablated low-voltage area. A protocol 600/350/300/300 ms was used for VT induction. An *acute success* was defined as non-inducibility of any VT, *partial success* as non-inducibility of clinical VT, and *acute failure* as inducibility of clinical VT. The *long-term success* was defined as no VT recurrence during the follow-up. A *success with rare recurrences* was defined as > 75 % reduction in VT recurrences over the same period of time– with or without antiarrhythmic medications, and other results were considered *non-successful*. The term electrical storm was defined as ≥ 3 separate episodes of VA in 24 h, each requiring termination by ICD or other intervention. Slow VT was defined at frequency < 140/min. The VT recurrence was defined as any VT of ≥ 30 s duration or VT with ICD interrogation (anti-tachycardia pacing or discharge).

Descriptive statistics was used for data presentation.

3. Results

From 317 consecutive patients (202 male, 64 %), structural heart disease was identified in 100 patients (31 %), 82 male (82 %). Out of these, the most prevalent underlying pathology was CAD (53 patients (53 %), 45 male (85 %)) followed by other cardiomyopathies (dilated–18, arrhythmogenic right ventricular–9, suspected myocarditis–6, congenital–5, hypertensive–4, valvular–4, and hypertrophic–1) (Figure 2).

Catheter ablation for sustained monomorphic VT was performed in 34/53 patients (64 %) with CAD due to amiodarone and beta-blocking drug treatment

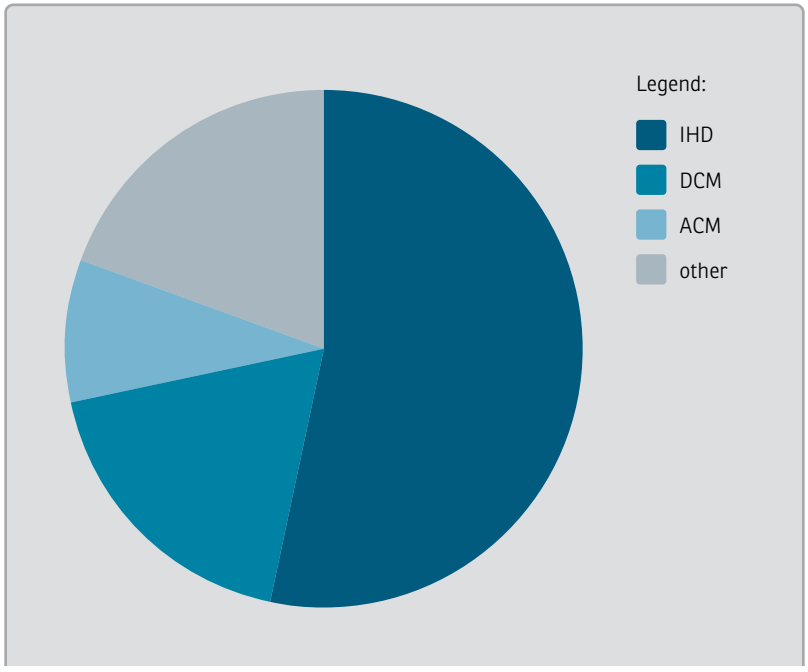

Figure 2: Patients with structural heart disease (n = 100, male 82) from our cohort of patients with ventricular tachyarrhythmias. Ischaemic heart disease (IHD) is the most prevalent (53 %), followed by dilative cardiomyopathy (DCM) and arrhythmogenic right ventricular cardiomyopathy (ACM). Among others are patients with suspected myocarditis, congenital disease, hypertensive cardiomyopathy, valvular cardiomyopathy, and hypertrophic cardiomyopathy.

failure or amiodarone withdrawal due to toxicity (Table 1). Significant comorbidities were present in majority of them (Table 1). Myocardial revascularization procedures were performed in 25/34 (73 %) patients–surgery in 15 (60 %) and percutaneous intervention in additional 10 patients (40 %). Electrical storm and slow VT were the most frequent initial presentations. ICD was implanted before the first ablation procedure in 23/34 patients (68 %) and in additional 8 afterwards. Therefore, 91 % of patients were treated with ICDs during the follow-up. The majority of VT ablation procedures were performed over the last years (Figure 3).

Scar-related re-entry due to remote myocardial infarction was the most frequent mechanism of VT seen in 30/34 patients (88 %). Scar was located in the infero-posterolateral area of the left ventricle in majority (24/30 patients, 80 %). Recurrent VA triggered by Purkinje-related or outflow-tract premature ventricular complex-related VA was suspected in 4/34 patients (11 %).

The 3-D electro-anatomical mapping system (CARTO) was used in 39/44 (89 %) of procedures. »Scar homogenization« approach was used in 27/44 procedures (61 %), »linear ablation« approach in 13/44 (30 %), and focal ablation in 4/44 (9 %) procedures. In all, only endocardial RF ablation was performed.

Acute success was tested at the end of the procedure in 32/44 procedures and the result was successful in 19/32 procedures (59 %), partially successful in 8/32 (25 %), and procedure failed in 5/32 (16 %). Testing was not performed in other 12 procedures because of hemodynamic instability and frequent electrical cardioversions/defibrillations during the procedure. There were no procedure-related deaths. A pericardial tamponade that needed surgical intervention occurred in one procedure (2 %). It was related to diagnostic catheter perforation at the right ventricular apex in a patient on dual antiplatelet therapy. Data for minor vascular access complications or transient heart failure exacerbation were incomplete, but definitely below 10 %. In 2/34 patients (6 %) incessant VT could not be terminated acutely (one patient died during the initial hospitalization and another after 2 months of follow-up, both due to uncontrollable slow VT with progression to heart failure).

Median (rank) follow-up time was 31 months (6–151). Seven patients died and 3 did not come to regular out-patient visits after 4, 11 and 82 months. Five patients died during 6 months of follow-up (2 during initial hospitalization–one due to uncontrollable slow VT mentioned before, another in terminal heart failure; others after 1, 2, and 3 months,

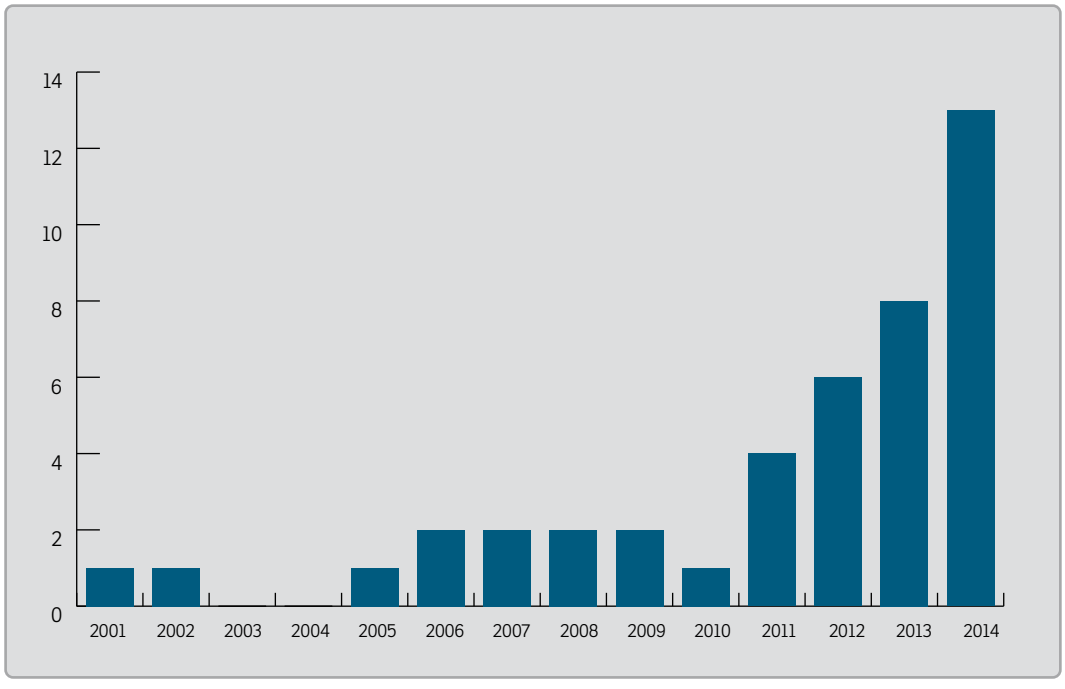

Figure 3: Number of ventricular tachycardia (VT) catheter ablation procedures per year in patients with ischemic heart disease (UCC Ljubljana). Numbers have been increasing over the last few years.

respectively). Other two patients died after 9, and 112 months of follow-up. No VT recurrences were documented after at least 6 months of follow-up in 20/34 patients (59 %, 1 with 3 procedures and 3 with 2 procedures) and rare VT episodes were documented in additional 4 (12 %; 22, 24, 36 and 48 months after ablation). Ten patients are without antiarrhythmic drugs, 6 on amiodarone and ranolazine, 6 on amiodarone, and 2 are on ranolazine alone. The majority of VT recurrences (75 %) were documented up-to 6 months after ablation procedure (Figure. 4).

4. Discussion

Our patients with IHD, in whom we performed endocardial RF catheter ablation for frequent VTs and ICD discharges, were typically male in their sixties, with ICM after remote inferior wall MI, after myocardial revascularization procedure, and with implanted ICD. Two-thirds of them presented with electrical storm. This report represents a single-centre retrospective clinical experience.

The scar homogenization ablation approach that we adopted recently is promising. However, a prospective randomized study is needed to provide the proof of scar homogenization superiority over the linear ablation approach. Nevertheless, the success rate (clinical benefit in 71 % of patients) and safety (one major complication in the series only) are acceptable and comparable to reported data from the world's leading centres (Table 2) (6,9-14). In another 13 studies with mean follow-up of 12 months or more, 50–88 % of patients were free of any VT, with 30–100 % continuing on previously ineffective antiarrhythmic medications (5). The efficacy of VT ablation was also emphasized in a recent on-

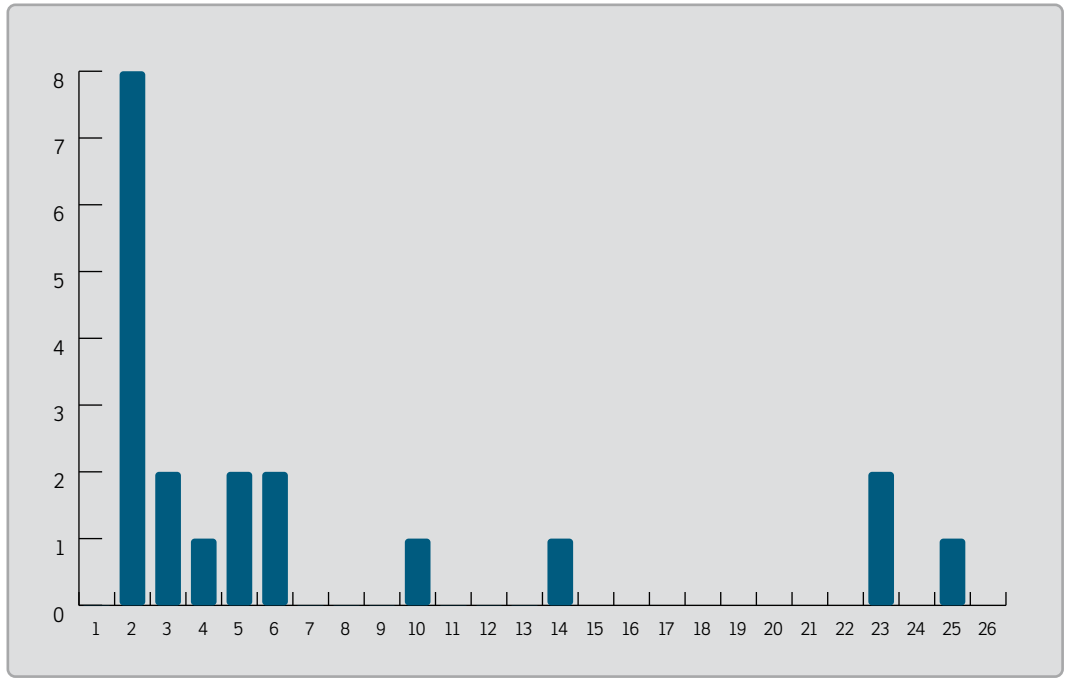

Figure 4: Number of patients with the first VT recurrence according to the month after ablation procedure. Early recurrences are possibly associated with ablation procedure failure and late-ones are due to disease progression.

-treatment analysis of the VTACH study in a similar group of patients as ours (7). VT ablation clearly prolonged time to recurrence of VA episodes and markedly decreased VA burden. In another recent report in patients with ICM, VT-free survival at 1-year follow-up was 57 % (15); almost identical result to ours.

The catheter ablation of VT is one of the most demanding interventional procedures in cardiology with additional safety risks for severely compromised patients. The prevalence of our VT ablation procedure complications are within the reported range. Procedure--related shock/death was reported in 0–3 %, stroke in 0–2.7 %, and perforation/tamponade in 0–2.7 %. Non-fatal minor complications occurred in 5–10 % of patients, including transient heart failure exacerbation, increase in mitral regurgitation, conduction block, and vascular access complications. Mortality during different follow-up periods ranged from 0 to 32 % (5).

After antiarrhythmic drug treatment failure, catheter-based irrigated-tip RF ablation remains the only reasonable treatment option. The use of novel 3-D electro-anatomical mapping systems are mandatory–for substrate characterization, VT activation mapping, catheter navigation, and contact-force measurements during ablation,–for a successful scar homogenization, which seems to be the most successful ablation approach. A novel high-density mapping technology is a particularly promising advancement in this regard. Non-inducibility of all VTs at the end of ablation procedure may be a good indicator for long-term ablation success, on top of the complete scar homogenization. Likewise, non-inducibility of all VTs was an independent predictor of VT recurrence in a recent study from Leipzig (15). However, this finding

Table 2: The comparing results of catheter VT ablation in patients with IHD from the world's leading centres.

Study	No of pts	EF (%)	Substrate	Targeted VT	Mapping	Acute success	Follow-up (months)	Follow-up success	Follow-up Mortality
Morady F, 1993* (9)	15	27 ± 8	ICM	Stable	VT	73 %	9 ± 3	80 %	-
Della Bella P, 2002* (10)	124	-	ICM	Stable	VT	73 %	41.5**	75 %	12 %
Kautzner J, 2003* (11)	28	28 ± 9	ICM	All	VT/ substrate	85 %	10 ± 6	78 %	-
Volkmeer M, 2006* (12)	47	30 ± 8	ICM	Clinical and slow	VT/ substrate	95 %	25 ± 13	75 %	-
Carbucicchio C, 2008* (13)	95	36 ± 11	ICM (75 %)	Electrical storm	VT/ substrate	89 %	22 ± 13	66 %	16 %
Stevenson WG, 2008*** (6)	231	25**	ICM	Clinical and slow	VT/ substrate	49 %	6**	53 %	18 %
Tanner H, 2009*** (14)	63	30 ± 13	ICM	All	VT/ substrate	81 %	12 ± 3	51 %	9 %
Šinkovec M, 2015*	34	35**	ICM	All / electrical storm	VT/ substrate	59 %	31** (> 6 months)	71 %	29 % (15 % up to 6 months)

** singlecenter study; ** median; *** multicenter study; VT – ventricular tachycardia, CAD – coronary artery disease, EF – left ventricular ejection fraction, ICM – ischaemic cardiomyopathy*

was not confirmed by others, since the inducibility of VT at the time of catheter ablation had no impact on long-term freedom from VA (16). This may be the consequence of different study designs with different ablation and stimulation protocols and needs further clarification.

5. Conclusion

Catheter ablation, performed in an experienced centre, should be considered early to reduce episodes of recurrent VT and ICD shocks in patients with IHD, even when multiple and hemodynamically intolerable VTs are present, like during the electrical storm. Two-thirds of these patient are doing well long-term after the ablation procedure. Approaches to guiding ablation are now well defined. A 3-D electro-anatomical mapping system is mandatory for substrate characterization and scar homogenization, which seems to be the most successful ablation strategy. Even in patients with multiple co-morbidities, procedure mortality and morbidity are acceptable. Our clinical experience is in compliance with the published recommendations (5).

6. Acknowledgement

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