

Follow-up after hemodynamically not tolerated ventricular tachycardia in patients with midrange reduced to normal ejection fraction: A retrospective single-centre case series

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Abstract

Introduction: The benefit of implantable cardioverter-defibrillator (ICD) implantation in patients with hemodynamically not tolerated ventricular tachycardia (VT) and midrange reduced to normal ejection fraction (LVEF >35%) is currently unclear. The purpose of this study was to investigate follow-up after hemodynamically not tolerated VT in patients with LVEF >35%. In addition, we aimed to find possible predictive factors to identify who will benefit from ICD implantation.

Methods: In a retrospective single-centre case series, all patients with hemodynamically not tolerated VT and LVEF >35% that underwent electrophysiological study (EPS) and/or radiofrequency VT ablation were included.

Results: Forty-two patients (5 women, median age 68 years) with hemodynamically not tolerated VT and LVEF >35% underwent EPS. VT ablation was performed in thirty-one patients, which was considered successful in twenty-three patients. Nineteen patients had an ICD at discharge while 23 patients were discharged without an ICD. The severity of hemodynamic compromise, LVEF and ablation success played an important role in the decision-making for ICD implantation. Six patients (14.3%) had recurrence of VT, all hemodynamically tolerated.

Conclusions: In this small case series, patients with hemodynamically not tolerated VT and LVEF >35% had a relatively low recurrence rate and all recurrences were nonfatal. Based on our results, we hypothesize that the severity of hemodynamic compromise, LVEF and ablation success might modify the risk for VA recurrence. A prospective study to determine the prognostic value of these factors in patients with hemodynamically not tolerated VT and LVEF >35% is necessary.

KEYWORDS

catheter ablation, hemodynamically not tolerated, implantable cardioverter-defibrillator, preserved ejection fraction, sudden cardiac arrest, ventricular tachycardia

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1 | INTRODUCTION

Ventricular tachycardia (VT) can cause a variety of clinical presentations, ranging from palpitations to sudden cardiac death (SCD). Cardiac arrest due to acute ventricular arrhythmias is the most common cause of SCD in developed countries.¹

Current guidelines recommend implantable cardioverter-defibrillator (ICD) implantation for secondary prevention of SCD in survivors of hemodynamically not tolerated VT in the absence of a reversible cause mainly based on three trials published between 1997 and 2000.² A meta-analysis of these three prospective trials demonstrated that ICD implantation in these patients reduced arrhythmic mortality with 50% in comparison with patients treated with antiarrhythmic drug therapy.³⁻⁶ This benefit was primarily confined to patients with reduced left ventricular ejection fraction (LVEF < 35%), patients with midrange reduced to normal LVEF appeared to obtain no benefit from an ICD.^{3,7} In spite of being life-saving devices, ICD's can cause several drawbacks such as infections, lead failure or painful inappropriate shocks.⁸ In addition, new ablation therapies may modify the risk for SCD and consequently the need for an ICD.⁹ This emphasizes the importance of re-evaluation of current guidelines and the need for new risk stratification strategies.

We performed a retrospective case study on the follow-up of patients with hemodynamically not tolerated VT and LVEF >35%. We hypothesized that the majority of these patients would have a relatively favourable prognosis and that therefore the clinical usefulness of ICD implantation might be debatable. In addition, we aimed to find possible predictive factors to identify who will benefit from ICD implantation.

2 | METHODS

2.1 | Study design

This retrospective cohort study included all patients with midrange reduced to normal LV function and hemodynamically not tolerated VT that underwent electrophysiological study (EPS) and/or VT ablation in the University Medical Center Utrecht (UMCU), the Netherlands between 01/01/2008 and 01/06/2018. This research obtained official approval by the Medical Research Ethics Committee UMC Utrecht following the Medical Research Involving Human Subjects Act (WMO). Reporting of the study conforms to broad EQUATOR guidelines.

2.2 | Data extraction

Patients were identified by a systematic search in the hospital's electronic health record system carried out by a data

manager. Patients with "Ventricular Tachycardia," "VT" or "no arrhythmias inducible" listed as diagnosis in their ablation registry form and/or operative report were identified. Patients with midrange reduced to normal LVEF and a hemodynamically not tolerated monomorphic VT in the absence of a reversible cause based on patient records were included in this study. Patients with a history of documented ventricular fibrillation without a preceding VT or a reversible cause were excluded.

Left ventricular ejection fraction was determined in eu-volemic state by echocardiography or MRI during or prior to hospitalization and considered midrange reduced to normal when above 35%. The VT was considered hemodynamically not tolerated in any of the following cases: (a) resuscitation due to a near-fatal VT; (b) syncope or near syncope during VT; (c) syncope or near syncope with at least one registration of a VT with similar complaints; or (d) hypotension during VT. Syncope was defined as a transient loss of consciousness. Near syncope was defined as a sense of impending faint without loss of consciousness. Hypotension was defined as systolic blood pressure (SBP) <100 mm Hg during VT and a significant drop of >20 mm Hg in comparison with the SBP during sinus rhythm.

Every patient endured EPS to identify a substrate responsible for the clinical VT by induction and mapping of the VT and/or identifying local abnormal ventricular activity (LAVA). If EPS identified, an accessible substrate for the clinical VT concurrent ablation was performed (targeted and local VT ablation, area-ablation and/or more extensive substrate modification). In some cases, inducibility testing after ablation was not performed due to the lack of an inducible VT during EPS or severe hemodynamic compromise during VT. Ablation was considered primarily successful if (a) the clinical VT was not inducible anymore after targeted ablation or (b) if LAVAs were successfully eliminated in case of a noninducible VT during EPS before ablation.

The New York Heart Association (NYHA) class was extracted from patient records. If the NYHA class was not given, the researcher determined the NYHA class based on documented symptoms following the official classification system.¹⁰ Haemoglobin and glomerular filtration rate (GFR) values prior to the procedure were extracted from patient records. Hypertension and diabetes were defined as known or newly diagnosed disease during hospital stay.¹¹

Follow-up data were extracted from patient records by reviewing hospitalization reports, consultation reports and ICD interrogations if available. In case of missing follow-up data, a national mortality check was conducted to check potential deaths. Living patients were called to find out if a recurrence had occurred, an ICD was implanted or an adjunctive ablation was carried out. Follow-up of deceased patients was collected by contacting the Cardiology department where the patient was treated before death.

2.3 | Statistical analysis

Analysis was performed using IBM SPSS Statistics version 25.0.0.0. Baseline and peri-procedural characteristics from patients with and without an ICD were compared. Continuous variables were presented as mean or median, and a Shapiro-Wilk test was performed to assess the normality of the distribution. An independent samples *t* test was conducted to compare normally distributed variables (such as LVEF), while a Mann-Whitney *U* test was conducted for the continuous non-normally distributed variables. Categorical variables were presented as percentages and were compared using Fisher's exact test using a two-sided *P*-value.

3 | RESULTS

3.1 | Clinical and peri-procedural characteristics of the study population

From 2009 till 2018, a total of 42 patients with a hemodynamically not tolerated VT and LVEF >35% underwent EPS and/or VT ablation at the UMCU. Baseline characteristics of the study population are shown in Table 1. The median age was 68 years, 88.1% was male. Most patients suffered from coronary heart disease (50%). In 21.4% of cases, no underlying heart disease was diagnosed. Most patients suffered from (near)syncope (54.8%), while others had hypotension (21.4%) or were resuscitated (23.8%) due to the VT. Resuscitated patients always had an underlying heart disease.

Forty-two patients underwent EPS, which was followed by radiofrequency ablation in 31 patients. Reasons for not performing an ablation after EPS were as follows: (a) the lack of a clear target for ablation; (b) severe hemodynamic instability during the procedure; (c) epicardial location of the substrate; or (d) substrate close to left bundle branch. The ablation was considered primarily successful in 23 of 31 patients. Peri-procedural patient characteristics are shown in Table 1.

Procedure-related complications were reported in four of 42 patients (9.5%). Complications were pericardial effusion, left bundle branch block, spurious aneurysm and hypovolemic shock due to groin bleeding. Nineteen patients (45.2%) had an ICD at the time of hospital discharge. Fifteen patients received ICD implantation during hospitalization while four patients already had an ICD. Thirty patients (71.4%) used antiarrhythmic drugs at the moment of discharge. In most cases, the treating physician described in the hospitalization report why an ICD was not implanted at the moment of discharge. Frequently given reasons are presented in Figure 1.

TABLE 1 Baseline characteristics of the study population

Variables	n = 42
Age, in years	68 [49-73]
Women	5 (11.9%)
Congestive heart failure	
NYHA I	33 (78.6%)
NYHA II	8 (19.0%)
NYHA III	1 (2.4%)
LVEF, in %	49 ± 8.1
Underlying disease	
Coronary heart disease	21 (50.0%)
Idiopathic	9 (21.4%)
Inflammatory cardiomyopathy	5 (11.9%)
Hypertensive cardiomyopathy	2 (4.8%)
Other	5 (11.9%)
Clinical manifestation of VT	
(Near) syncope	23 (54.8%)
Hypotension	9 (21.4%)
Resuscitation	10 (23.8%)
Index VT deteriorated to VF	5 (11.9%)
Hypertension	13 (31.0%)
Diabetes	7 (16.7%)
GFR	80 [60-90]
Haemoglobin	9.2 [8.6-9.6]
Characteristics of VT	
Left ventricle	30 (71.4%)
Procedure performed	
EPS without ablation	11 (26.2%)
Not or partially successful ablation	8 (19.0%)
Primarily successful ablation	23 (54.8%)
Complications	4 (9.5%)
ICD at discharge	19 (45.2%)
Antiarrhythmic therapy at discharge	30 (71.4%)

Note: Idiopathic: no underlying heart disease known. Data are presented as mean ± standard deviation, median [interquartile range] or number (percentage). Abbreviations: EPS, electrophysiological study; GFR, glomerular filtration rate; ICD, implantable cardioverter-defibrillator; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; VT, ventricular tachycardia.

3.2 | Mortality

The median follow-up time was 935 days (IQR 597 to 1443). In total five patients died, all due to a noncardiovascular cause without recurrence of VT (Figure 2). Two patients died due to a pneumonia while the other three patients died due to a malignancy.

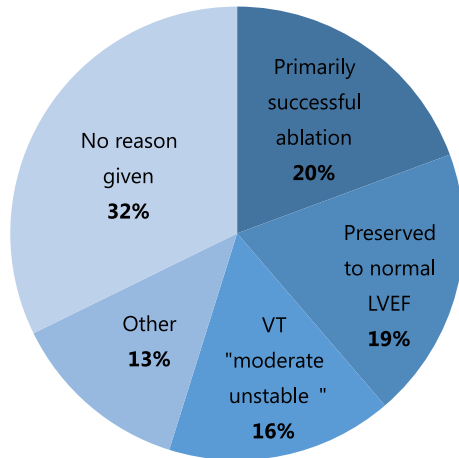


FIGURE 1 Reasons given by physicians to refrain from implantable cardioverter-defibrillator (ICD) implantation

3.3 | Recurrence of ventricular tachycardia

After discharge, in total six patients (14.3%) had recurrence of VT, all hemodynamically tolerated. The median time to recurrence was 164 days, ranging from 12 to 764 days. Two patients without an ICD (8.7%) had recurrence of VT. One patient received an ICD, while the other patient underwent re-ablation. Four patients with an ICD (21.0%) had recurrence of VT and received therapy from their device; one patient received multiple conscious shocks while the other three patients received anti-tachycardia pacing. Patients without VT recurrence did not receive inappropriate ICD therapy. One ICD was explanted due to a fractured lead in a patient without recurrence of VT. Follow-up after EPS/VT ablation is summarized in Figure 2.

3.4 | Comparison between patients with and without an ICD

Characteristics of patients with hemodynamically not tolerated VT and LVEF >35% that were discharged with and without an ICD were compared (Table 2). One resuscitated patient

did not receive ICD implantation due to high risk of infection as a result of a large wound. Amiodarone was prescribed instead. Patients with an ICD had significant lower LVEF and more frequently had structural heart disease (SHD). Patients with an ICD had been resuscitated significantly more often at baseline due to the VT and more frequently they had their VT deteriorate into VF. Additionally, patients with an ICD had significantly lower ablation success rates.

4 | DISCUSSION

This study supports the view that a uniform management including ICD implantation for all patients with hemodynamically not tolerated VT and LVEF >35% may not be optimal. Nineteen patients were discharged with an ICD, while 23 patients did not have an ICD at discharge. In both groups, zero patients died due to an arrhythmia. Importantly, only six patients (14.3%) had recurrence of VT, all hemodynamically tolerated.

No previous trials investigated clinical usefulness of ICD implantation in this specific population. However, three large prospective trials (the AVID,⁴ CASH⁵ and CIDS⁶ trial) compared the effect of ICD implantation versus antiarrhythmic drug therapy in patients with ventricular arrhythmias. A meta-analysis of these trials showed in a subgroup analysis that patients with hemodynamically not tolerated VT and LVEF >35% obtain little or no benefit from an ICD.³ Our results seem consistent with these findings. Interestingly, all recurrences were hemodynamically tolerated, which may be due to the effect of drug and/or ablation therapy. This is the first study, to the best of our knowledge, investigating the follow-up of patients who presented with hemodynamically not tolerated VT and LVEF >35%.

4.1 | Predictive factors of VT recurrence

Our study showed that in clinical practice, the severity of hemodynamic compromise, underlying SHD, LVEF and ablation success play an important role in the decision-making for ICD implantation after VT (Table 2). It is conceivable that

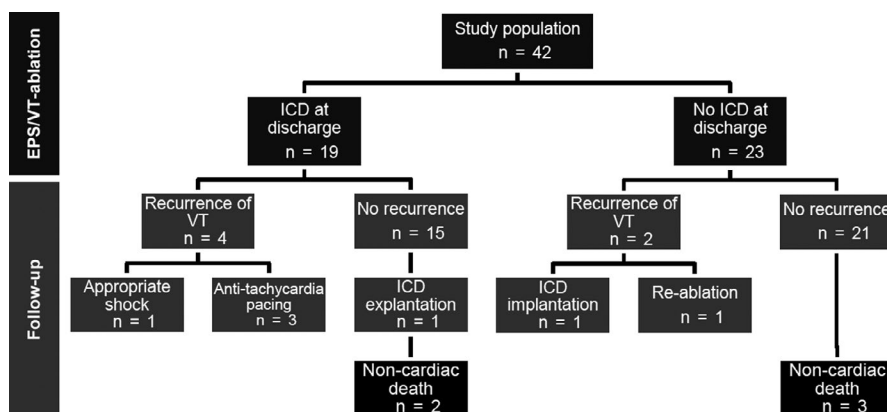


FIGURE 2 Follow-up after hemodynamically not tolerated ventricular tachycardia (VT)

TABLE 2 Comparison between patients with and without an ICD at the time of discharge

Variables	ICD n = 19 (45%)	No ICD n = 23 (55%)	P- value
Age (years)	70 [58-73]	59 [47-73]	.277
Women	2 (10.5%)	3 (13.0%)	1.000
Congestive heart failure			
NYHA I	13 (68.4%)	20 (86.9%)	.260
NYHA II	6 (31.6%)	2 (8.7%)	.115
LVEF (%)	46 [43-50]	53 [44-57]	.036*
Underlying disease			
Coronary heart disease	12 (63.2%)	9 (39.1%)	.215
Idiopathic	0 (0%)	9 (39.1%)	.002*
Inflammatory cardiomyopathy	2 (10.5%)	3 (13.0%)	1.000
Other	5 (26.3%)	2 (8.7%)	.214
Clinical manifestation of VT			
(Near) syncope	7 (36.8%)	16 (69.6%)	.061
Hypotension	3 (15.8%)	6 (26.1%)	.477
Resuscitation	9 (47.4%)	1 (4.3%)	.002*
Index VT deteriorated to VF	5 (26.3%)	0 (0%)	.014*
Primarily successful ablation	6 (31.6%)	17 (73.9%)	.012*
Antiarrhythmic therapy at discharge	16 (84.2%)	14 (60.9%)	.169

Note: Idiopathic: no underlying disease known, Sustained VT: >30 s. Variables are denoted as median [interquartile range] or number (percentage).

Abbreviations: ICD, implantable cardioverter-defibrillator; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; VT, ventricular tachycardia.

*P-value <.05 was considered statistically significant.

patients with LVEF >45% might have a more favourable prognosis than patients with LVEF 35%–45%. We observed that in patients with VA recurrence the median LVEF was 42%, while in patients without VA recurrence the median LVEF was 50%. In addition, patients with a primarily successful ablation showed lesser recurrence of VA (Table 3). Due to a small sample size and low event rates, multivariate analysis could not be performed in this study. Consequently, the prognostic value of these parameters remains unknown. However, we cautiously hypothesize that some of these parameters might have a predictive value for VA recurrence in this patient group.

4.2 | Idiopathic ventricular tachycardia

In our study, 9 (21.4%) patients had no underlying SHD. On both echo and CMR, no SHD or evident delayed enhancement were seen. Most patients with idiopathic VT (without SHD)

TABLE 3 Characteristics of patients with and without recurrence VT

Variables	Recurrence of VT	
	Yes n = 6 (14%)	No n = 36 (86%)
Age, in years	66 [28-75]	68 [49-75]
Women	0 (0%)	5 (13.9%)
LVEF, in %	42 [39-56]	50 [45-54]
LVEF < 45%	4 (66.7%)	8 (22.2%)
Underlying disease		
Coronary heart disease	4 (66.7%)	17 (47.2%)
Idiopathic	1 (16.7%)	8 (22.2%)
Inflammatory cardiomyopathy	0 (0%)	5 (13.9%)
Other	1 (16.7%)	6 (16.7%)
Clinical manifestation of VT		
(Near) syncope	4 (66.7%)	19 (52.8%)
Hypotension	0 (0%)	9 (25.0%)
Resuscitation	2 (33.3%)	8 (22.2%)
Index VT deteriorated to VF	0 (0%)	5 (13.9%)
Procedure performed		
EPS without ablation	2 (33.3%)	9 (25.0%)
Not or partially successful ablation	2 (33.3%)	6 (16.7%)
Primarily successful ablation	2 (33.3%)	21 (58.3%)
Antiarrhythmic therapy at discharge	3 (50.0%)	27 (75.0%)

Note: Variables are denoted as median [interquartile range] or number (percentage).

Abbreviations: EPS, electrophysiological study; LVEF, left ventricular ejection fraction; VT, ventricular tachycardia.

present with mild symptoms and have a low risk for sudden cardiac death, an ICD is typically not indicated.¹² However, a subset of patients with idiopathic VT tend to have a higher risk for SCD. The predictors for SCD in this group remain uncertain, but hemodynamic instability during VT has been proposed as a risk factor.^{12,13} Since these patients may benefit from ICD implantation due to a higher risk for SCD, we chose to include these patients. We observed that in patients with idiopathic VT, less frequently an ICD was implanted than in patients with SHD (Table 2). However, we also observed VA recurrence in one patient with idiopathic VT. The risk of SCD in these patients remains unknown and should be further studied.

4.3 | “Hemodynamically not tolerated” as main determinant for ICD implantation

In our cohort, angina during a VT was considered hemodynamically tolerated. However, angina during a VT could

be a sign of coronary hypoperfusion and therefore also be interpreted as hemodynamically not tolerated.¹⁴ Near syncope during a VT could be due to hypotension but it could also be due to a vagal response. Other symptoms, such as shortness of breath and dizziness, can also be diversely interpreted. This demonstrates the lack of a clear definition. Current guidelines² use “hemodynamically not tolerated” as only determinant for ICD implantation in VT patients primarily based on data from the AVID,⁴ CASH⁵ and CIDS⁶ trial. However, these trials had noticeably different inclusion criteria ranging from resuscitated patients only to patients with LVEF <35% and complaints of congestive heart failure or angina. Our study showed that the severity of hemodynamic compromise does influence the decision-making for ICD implantation after hemodynamically not tolerated VT in clinical practice. In patients with near syncope, an ICD was less frequently implanted than in patients that were resuscitated due to a VT (Table 2). Although we cannot say this with certainty, it is conceivable that the severity of hemodynamic compromise during VT does influence the risk for SCD. Consequently, using “hemodynamically not tolerated” as main determinant for ICD implantation in VT patients with all above mentioned uncertainties seems questionable.

4.4 | EPS and catheter ablation

In our study, 73.8% of patients received catheter ablation. Catheter ablation significantly reduces recurrence of VT, and observational studies indicate that a successful catheter ablation also reduces mortality.^{9,15-18} A large multicentre retrospective study showed that a successful catheter ablation as primary treatment without concurrent ICD implantation in patients with hemodynamically tolerated VT and LVEF >30% was associated with a low rate of SCD (2.4%).¹⁹ In addition, the all-cause mortality rate of patients with and without an ICD was similar (12%). Our study showed that a successful catheter ablation does influence the decision-making for ICD implantation after hemodynamically not tolerated VT in clinical practice. One could speculate that, since recurrence of VT in patients with a primarily successful ablation is lower, ICD implantation could be overcome in some of these patients, although further studies are needed. Prospective trials powered to examine the effect of VT ablation on mortality have not yet been performed.

4.5 | Limitations

This is a single-centre retrospective case series with all limitations of such a study. The sample size of this study was small,

and no uniform ablation or treatment strategy was enforced therefore creating a heterogeneous cohort. Therefore, the prognostic value of our results remains unknown. Interestingly, in 32% of patients without an ICD there was no reason documented to refrain from ICD implantation. We expect that in most cases the reason was discussed, but unfortunately not documented in the patient's file. Our patient is cohort heterogeneous but does represent the current situation in clinical practice and consequently displays some of the difficulties for cardiologists. Our results should therefore be seen as hypothesis generating to guide researchers in future studies.

5 | CONCLUSION

In this small case series, patients with hemodynamically not tolerated VT and LVEF >35% had a relatively low recurrence rate and all recurrences were nonfatal. We identified possible predictive factors of VA recurrence. Based on our results, we hypothesize that the severity of hemodynamic compromise, LVEF, underlying SHD and ablation success might modify the risk for VA recurrence. A prospective study to determine the prognostic value of these factors in patients with hemodynamically not tolerated VT and LVEF >35% is necessary.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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REFERENCES

1. Deo R, Albert CM. Epidemiology and genetics of sudden cardiac death. *Circulation*. 2012;125(4):620-637.
2. Priori SG, Blomström-Lundqvist C, Mazzanti A, et al. 2015 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death. *Eur Heart J*. 2015;36(41):2793-2867.
3. Connolly S. Meta-analysis of the implantable cardioverter defibrillator secondary prevention trials. *Eur Heart J*. 2000;21(24):2071-2078.
4. The Antiarrhythmics versus Implantable Defibrillators (AVID) Investigators. A comparison of antiarrhythmic-drug therapy with implantable defibrillators in patients resuscitated from near-fatal ventricular arrhythmias. *N Engl J Med*. 1997;337(22):1576-1584.
5. Kuck K-H, Cappato R, Siebels J, Ruppel R. Randomized comparison of antiarrhythmic drug therapy with implantable defibrillators in patients resuscitated from cardiac arrest. *Circulation*. 2000;102(7):748-754.
6. Connolly SJ, Gent M, Roberts RS, et al. Canadian Implantable Defibrillator Study (CIDS). *Circulation*. 2000;101(11):1297-1302.
7. Domanski MJ, Sakseena S, Epstein AE, et al. Relative effectiveness of the implantable cardioverter-defibrillator and antiarrhythmic

- drugs in patients with varying degrees of left ventricular dysfunction who have survived malignant ventricular arrhythmias. *J Am Coll Cardiol.* 1999;34(4):1090-1095.
8. van der Heijden AC, Borleffs CJW, Buiten MS, et al. The clinical course of patients with implantable cardioverter-defibrillators: extended experience on clinical outcome, device replacements, and device-related complications. *Heart Rhythm.* 2015;12(6):1169-1176.
 9. Dukkipati SR, Koruth JS, Choudry S, Miller MA, Whang W, Reddy VY. Catheter ablation of ventricular tachycardia in structural heart disease. *J Am Coll Cardiol.* 2017;70(23):2924-2941.
 10. The Criteria Committee of the New York Heart Association. *Nomenclature and Criteria for Diagnosis of Diseases of the Heart and Great Vessels.* 9th edn. Boston, MA: Little, Brown & Co.; 1994.
 11. Cosentino F, Grant PJ, Aboyans V, et al. 2019 ESC Guidelines on diabetes, pre-diabetes, and cardiovascular diseases developed in collaboration with the EASD. *Eur Heart J.* 2020;41(2):255-323.
 12. Dukkipati SR, Choudry S, Koruth JS, Miller MA, Whang W, Reddy VY. Catheter ablation of ventricular tachycardia in structurally normal hearts. *J Am Coll Cardiol.* 2017;70(23):2909-2923.
 13. Tan AY, Ellenbogen K. Ventricular arrhythmias in apparently normal hearts: who needs an implantable cardiac defibrillator? *Card Electrophysiol Clin.* 2016;8(3):613-621.
 14. Sevransky J. Clinical assessment of hemodynamically unstable patients. *Curr Opin Crit Care.* 2009;15(3):234-238.
 15. Reddy VY, Reynolds MR, Neuzil P, et al. Prophylactic catheter ablation for the prevention of defibrillator therapy. *N Engl J Med.* 2007;357(26):2657-2665.
 16. Kuck K-H, Schaumann A, Eckardt L, et al. Catheter ablation of stable ventricular tachycardia before defibrillator implantation in patients with coronary heart disease (VTACH): a multicentre randomised controlled trial. *Lancet.* 2010;375(9708):31-40.
 17. Kuck K-H, Tilz RR, Deneke T, et al. Impact of substrate modification by catheter ablation on implantable cardioverter-defibrillator interventions in patients with unstable ventricular arrhythmias and coronary artery disease. *Circ Arrhythmia Electrophysiol.* 2017;10(3):e004422.
 18. Sapp JL, Wells GA, Parkash R, et al. Ventricular tachycardia ablation versus escalation of antiarrhythmic drugs. *N Engl J Med.* 2016;375(2):111-121.
 19. Maury P, Baratto F, Zeppenfeld K, et al. Radio-frequency ablation as primary management of well-tolerated sustained monomorphic ventricular tachycardia in patients with structural heart disease and left ventricular ejection fraction over 30%. *Eur Heart J.* 2014;35(22):1479-1485.

How to cite this article: Groeneveld SA, Blom LJ, van der Heijden JF, Loh P, Hassink RJ. Follow-up after hemodynamically not tolerated ventricular tachycardia in patients with midrange reduced to normal ejection fraction: A retrospective single-centre case series. *Eur J Clin Invest.* 2021;51:e13359. <https://doi.org/10.1111/eci.13359>