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CATHETER ABLATION FOR VENTRICULAR ARRHYTHMIAS USING REMOTE MAGNETIC NAVIGATION IN PATIENTS WITH REDUCED EJECTION FRACTION

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Abstract. **Objective.** Radiofrequency catheter ablation is an effective treatment option for cardiac arrhythmias including complex and ventricular arrhythmias. Remote magnetic catheter navigation (RMN) has been developed as a novel way of approach aiming to improve outcome and reduce complication rate, and reduce radiation exposure for both operator and patient. Our aim was to compare success and complication rate in patients with or without severely reduced left ventricular ejection fraction (LVEF). **Methods.** We retrospectively analyzed all the patients (n = 98) which have undergone RMN in our center between 2015-2021. No selection criteria for RMN procedure have been applied. All clinical and paraclinical, as well as procedural data were collected. Patients were divided into two groups, with or without severely reduced LVEF ≤ 35%. CARTO system was used for 3D electroanatomic mapping. RMN was done using Niobe ES system and an open-irrigated magnetic ablation catheter. Success rate was defined by complete elimination of clinical arrhythmia. Non-inducibility following ablation was assessed in all patients presenting with any type of ventricular arrhythmia other than premature ventricular contractions. Testing for inducibility was done by ventricular programmed pacing with up to four extra-stimuli. The statistical analysis was performed using SPSS software. P-value < 0.05 was considered significant. **Results.** Successful ablation with complete elimination of the clinical arrhythmia was achieved in 92.3% of the patients with severely reduced LVEF and in 88.1% of patients with LVEF > 35% (p = 0.73). Overall minor complication rate was 2.04% with spontaneous resolution. No major complications were reported. Non-inducibility was achieved in 56.4% of the patients with LVEF ≤ 35% and in 79.2% of the patients with LVEF >35% (p = 0.023). **Conclusion.** Radiofrequency catheter ablation using RMN is effective and safe regardless of the presence or not of a severely reduced LVEF.

Key words: catheter ablation; ventricular arrhythmias; remote magnetic navigation; reduced left ventricular ejection fraction

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Introduction

Radiofrequency catheter ablation has emerged as an effective treatment option for drug-refractory recurrent ventricular arrhythmias [1-4]. Over the past years, important technological advances have led to the development of novel approaches including 3D real-time cardiac anatomical mapping and remote magnetic catheter navigation (RMN) offering a precise and flexible catheter navigation [5, 6], increasing efficacy and reducing complication rate of radiofrequency catheter ablation procedures [7]. Additional benefits are reduced radiation exposure [8-9] to both operator and patient, and reduced physical stress for the physician [10]. Those procedural benefits have especially been proven in the setting of ventricular tachycardia (VT) ablation in structural heart disease [9, 11].

The RMN ablation procedure components are the Niobe ES system (Stereotaxis Inc., St. Louis, Missouri), the CARTO 3D mapping system (Biosense Webster Inc., Carlsbad, California), and an open-irrigated magnetic ablation catheter (NaviStar RMT ThermoCool, Biosense Webster Inc.). Two permanent magnets are installed on both sides of the radio-transparent examination table which create a 0.08-0.10 T magnetic field inside the patient's chest, and by continuously changing the orientation of the magnets, effective control of the magnetic catheter deflection is achieved and so the catheter is remotely maneuvered to map and reach different anatomical sites [12].

Underlying myocardial disease and overall cardiac performance strongly influence the outcome and risks of complications. While the current mainstem therapy for prevention of sudden cardiac death related to ventricular arrhythmias is the implantable cardioverter-defibrillator (ICD) [13], effective ablation in patients with ICD/cardiac resynchronization therapy with defibrillator support (CRT-D) significantly reduces the number of appropriate ICD therapies delivered. Our goal was to describe the difference of characteristics and outcomes between patients with or without severely reduced left ventricular ejection fraction (LVEF), referred to our center for catheter ablation, for which the best approach was chosen to be remote magnetic catheter navigation.

Methods

All patients requiring RMN from 2015 to 2021 (a total of 98 patients) were retrospectively analyzed. Patients were divided into two groups, with or without severely reduced LVEF (LVEF ≤ 35% was considered severely reduced). Clinical and paraclinical information was collected, as well as intra-procedural data. 3D electro-anatomic mapping was done using CARTO v.IV and NaviStar RMT ThermoCool. Left ventricular (LV) access in patients with structural heart disease was achieved predominantly via transseptal puncture (Fig. 1).

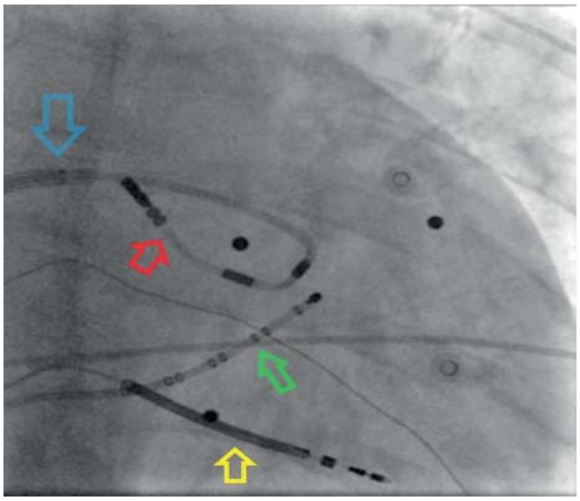

Fig. 1. ● Transseptal puncture sheath; ● NaviStar RMT ThermoCool catheter; ● Coronary sinus catheter; ● Right ventricular ICD lead

Whenever possible, cardiac magnetic resonance imaging (MRI) with late gadolinium enhancement was performed before the procedure, irrespective of the underlying cardiomyopathy [idiopathic dilated cardiomyopathy, ischaemic heart disease, arrhythmogenic right ventricular cardiomyopathy, etc.]. Success rate was defined as elimination of the clinical arrhythmia. Non-inducibility was recorded for all patients requiring testing after ablation [i.e., patients presenting with non-sustained VT or monomorphic VT]. Patients presenting with frequent premature ventricular contractions (PVC) were not subject to inducibility testing after completing the ablation. Non-inducibility was defined by failure to induce any kind of ventricular arrhythmia by programmed ventricular pacing, including VT other than the clinical arrhythmia, and ventricular fibrillation. Inducibility for ventricular arrhythmias was assessed using programmed ventricular pacing with up to 4 extra-stimuli. Inducibility was assessed down to refractoriness or to a shortest coupling interval of 200 msec, whichever came first. All patients had a coronary sinus catheter inserted and in stand-by for different purposes (pacing, differential diagnosis). Regarding statistical analysis, category variables were presented as both numbers and percentages and compared using the chi-square test. Continuous variables were presented as averages and interquartile range (IQR, defined as the difference between the 3rd and 1st quartiles) and compared using Student's t-test or ANOVA. When dealing with data with non-normal distribution, Wilcoxon sum rank test and Fischer's exact test were used. The statistical analysis was performed using SPSS software.

Results

Of the total 98 patients with ventricular arrhythmias requiring RMN ablation included in the analysis, 62 (63.2%) were males, 69 (70.4%) had structural heart disease, 39 (39,7%) had severely reduced LVEF (rLVEF), with only one case of rLVEF = 25% bound to cardiomyopathy due to frequent PVCs. Only 10 patients (10.2%) had tachycardiomyopathy with different grades of LVEF reduction varying between LVEF 40% and 50% assessed by either echocardiographic or cardiac MRI evaluation. Single or dual chamber ICD was present in 21 patients (21.4%), while only 10 patients (10.2%) had CRT-D device. Of those with structural heart disease, 41 had ischemic heart disease, 16 had idiopathic dilated cardiomyopathy, 4 had arrhythmogenic right ventricular cardiomyopathy, 3 had post-focal myocarditis cardiomyopathy, 2 had valvular cardiomyopathy with previous surgery, 2 had non-compaction cardiomyopathy, 1 had hypertrophic cardiomyopathy. Male patients in the group with severe rLVEF were 84.6%, at a mean age of 62.2 years (IQR 13), and ischemic heart disease accounted for 69.2% of this group. VT storm was the most frequent clinical arrhythmia presenting in this group and accounted for 69.2% of the cases, followed by monomorphic VT in 23.1%, and PVCs in 7.7% (Table 1).

Acute procedural success defined by elimination of the clinical arrhythmia was achieved in 36 patients (92.3%) in the group with rLVEF vs. 52 (88.1%) in the group with LVEF > 35%, p = 0.73.

Non-inducibility was reached in 22 (56.4%) of the patients in the rLVEF group, while the percentage was much higher in the group with LVEF > 35%, accounting for 42 patients (79.2%) of the latter group, p = 0.023.

Regarding success rates, among the analyzed data, only younger age and RV ablation sites could predict the outcome of success (p = 0.023, and p = 0.035, respectively). Other parameters such as LVEF ≤ 35%, patient sex, type of ventricular arrhythmias, presence of ischaemic heart disease, epicardial or transseptal approach, were not significant predictors of success (Fig. 2).

Table 1. Patients' characteristics

	LVEF ≤ 35% (n = 39)	LVEF > 35% (n = 59)	P
Males, n (%)	33 (84.6 %)	29 (49.2 %)	0.001
Age, m (IQR)	62.2 (13)	46.8 (25)	< 0.001
Diagnosis, n (%) – PVC – VT – VT Storm	 3 (7.7%) 9 (23.1%) 27 (69.2%)	 39 (66.1%) 10 (16.9%) 10 (16.9%)	Global P value < 0.001
Ischaemic heart disease, n (%)	27 (69.2 %)	14 (23.7 %)	< 0.001

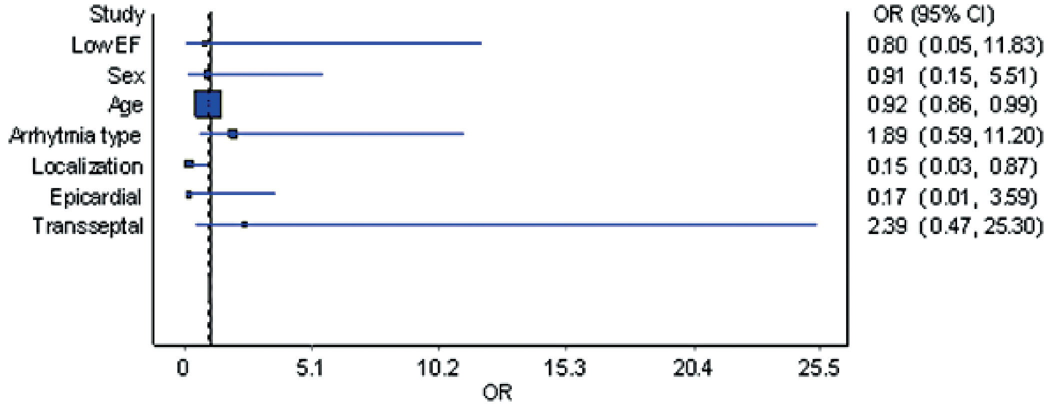

Fig. 2. Predictors of ablation success

The right ventricle was targeted for ablation in 5.1% of the patients with rLVEF (vs. 40.7% in the group with LVEF > 35%), the LV in 59% of the patients with rLVEF (vs. 52.5%), and in 35.9% of the patients with rLVEF ablation was performed in both ventricles (intramural site, multiple sites with similar early-activation times in both ventricles) vs. 6.8% of those with LVEF > 35%. LV access was achieved via atrial transseptal puncture in 89.7% of the cases with rLVEF (vs. 39.7% in patients with LVEF>35%), while epicardial access via percutaneous transpericardial puncture was done in 16.7% (vs. 3.4%).

Procedure-related complications were only two: one right atrium – aortic non-coronary sinus fistula due to an inadequate antero-superior transseptal puncture which resolved spontaneously after one month of follow-up without further need of medical intervention, and one case of right coronary artery air embolism from the right atrium through a patent foramen ovale. The embolization resolved spontaneously during the procedure with no further sequelae. There were no complications from the retrograde transaortic approach (incl. damage to the aortic valve), which was used in 20 patients (20.4%).

Discussion

Our study reports procedural success rate of 92.3% and 88.1% in patients with and without rLVEF respectively, which is similar to recent studies published in the literature [14]. Success rates in similar studies vary between 80% [15] and 100% [16]. Lack of success was observed mainly in patients with challenging location of the arrhythmia origin such as peri-Hissian area, right bundle branch or LV summit, or epicardial origin of the circuit in patients with previous pericardial intervention and adhesions impeding even surgical pericardial approach, or multiple ablation sites suggesting an extensively damaged underlying myocardium. Patients with severely reduced ejection fraction were significantly more prone to still have inducible ventricular arrhythmias after performing the ablation. Overall, the complication rate was 2.04% with no serious or major complication. Patients with reduced LVEF were significantly older, were more likely to be males, and more likely to present with VT storm and ischaemic heart disease. Our experience suggests that using RMN can increase safety and efficacy of the procedure especially in challenging arrhythmia locations (papillary muscle, peri-Hissian foci, aortic cusps, etc.) and in heavily modified cardiac anatomy (enlarged ventricles, post-surgical modified anatomy). One of the major advantages of the RMN procedure is the soft catheter used for cardiac electro-anatomical mapping (and ultimately ablation), as the final map is more accurate due to the lack of map distortion caused by rigid classic catheters which typically can overestimate the chamber that is being mapped. Another major advantage is the stability of the catheter during ablation, which increases the catheter-tissue contact and less energy, less time, and less lesion size are needed for effective ablation. Further investigation is needed to confirm our findings. Although there have been no selection criteria for RMN procedure, we realize that a certain selection bias could have occurred.

Conclusion

Radiofrequency catheter ablation using RMN is safe and effective for ventricular arrhythmias regardless of the patient's ejection fraction. RMN approach is possibly superior to standard approach especially in challenging arrhythmia locations and modified cardiac anatomy.

No conflict of interest was declared

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