Ablation Targets of Scar-related Ventricular Tachycardia Identified by Dynamic Functional Substrate Mapping

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Methods

Patients

Consecutive patients presenting to Ain Shams University hospitals for ablation of ventricular tachycardia were evaluated for participation in the study. Patient recruitment period was from October 2021 till January 2023. Approval was obtained from the ethical committee at Ain shams University before starting the research.

- ***Inclusion criteria***
    - Patients with structural heart disease including previous myocardial infarction, left ventricular (LV) dilatation and/or systolic dysfunction, or normal LV diameters and systolic function with evidence of ventricular scar on contrast enhanced-cardiac magnetic resonance (ce-CMR) or electroanatomic map (EAM).
    - Sustained monomorphic VT documented by 12-lead electrocardiogram (ECG) or implantable cardioverter defibrillator (ICD) electrograms resistant to antiarrhythmic drug treatment or requiring ICD therapies.
- ***Exclusion criteria***
    - Patients with ventricular arrhythmias attributed to reversible causes.

Methods:

On admission, patients were subjected to the following after a written informed consent:

A. History taking:

1. Age & sex.
2. Smoking status.
3. Medical history including hypertension (HTN), diabetes mellitus (DM), renal

impairment, etc.

4. Previous history of coronary artery disease, myocardial infarctions (MI), revascularization procedures
5. Previous episodes of ventricular tachycardia, requirement for external shock, ICD shocks.
6. Medical treatment with special emphasis on antiarrhythmic drugs.

B. Physical examination: with special emphasis on vital data including general & local examination.

C. 12 lead surface ECG: during sinus rhythm and of VT(s); if available.

D. Laboratory investigations: Including serum electrolytes, kidney function

E. Echocardiography will be done routinely for all patients with special emphasis on ejection fraction (to be assessed by Simpson's method), left ventricular dimensions, resting segmental wall motion abnormalities (RSWMAs).

F. Coronary angiography according to the patient's clinical characteristics; if there is doubt about coronary artery disease as contributor to VT or LV dysfunction.

G. Randomization:

Patients were randomly allocated to either DEEP group or non-DEEP group before the procedure. Patients were informed of the group to which they have been randomized.

H. Procedure:

The electrophysiological study and ablation was conducted under general anesthesia under supervision of an anesthesiologist. Continuous Non-invasive or intra-arterial blood pressure monitoring and digital pulse oximetry were performed. ICD therapies were inactivated.

Vascular sheaths were inserted into the right femoral vein (2 to 3), right femoral artery and/or subxiphoid area under local anesthesia (bupivacaine). A steerable quadripolar or decapolar catheter was positioned in the right ventricular apex or coronary sinus. The access was via endocardial retroaortic approach, trans-septal approach, epicardial approach or endocardial retroaortic with ad-hoc epicardial approach. Epicardial mapping and ablation was performed when preprocedural ce-

CMR showed epicardial scar, endocardial mapping did not identify subendocardial scars, unipolar LV mapping suggested the presence of epicardial scar, ECG of clinical or induced VT suggests epicardial origin (Berruezo *et al.*, 2004) (Vallès, Bazan and Marchlinski, 2010). The right ventricle (RV) was mapped when right ventricular origin of VT was supected e.g. in arrhythmogenic right ventricular cardiomyopathy (ARVC). Surface electrocardiograms (ECGs) and bipolar intracardiac electrograms were continuously monitored.

I. Mapping and Ablation Strategy:

All patients underwent bipolar voltage mapping during sinus rhythm. Mapping was performed by either an irrigated tip ablation catheter (ThermoCool SF™ catheter; Biosense Webster, Diamond Bar, CA, USA), (ThermoCool ST™ catheter; Biosense Webster, Diamond Bar, CA, USA), (FlexAbility ™; Abbott, St. Paul, MN, USA), (TactiCath™; Abbott, St. Paul, MN, USA) or a multi-electrode mapping catheter (Pentaray™, Biosense Webster, Diamond Bar, CA, USA). Late potentials (LPs) (defined as sharp high frequency or fractionated potentials at or after the terminal portion of QRS (Arenal *et al.*, 2003)) were pinpointed and tagged.

Patients allocated to the DEEP group were subjected to further analysis of their LPs by RV extrastimulus pacing. This constituted an S1 drive train at 600 ms or 500 ms (according to the sinus rhythm cycle length) followed by a single S2 extrastimulus at 20 ms longer than the ventricular effective refractory period. Thereafter, the time interval from the surface ventricular far-field signal to the local bipolar LP electrogram was measured both during the RV drive train and with S2 extrastimualtion. If the difference between the 2 measured values was > 10 ms, the analyzed LP was annotated as a DEEP. The same applied for multicomponent signals where DEEP was annotated if there was a more than 10 ms splitting of components in response to S2 (Figure 1) (Porta-Sánchez *et al.*, 2018). The percentage of points with LPs and DEEPs was calculated in relation to the total number of mapped points.

Figure (1): Intracardiac electrogram demonstrating DEEP

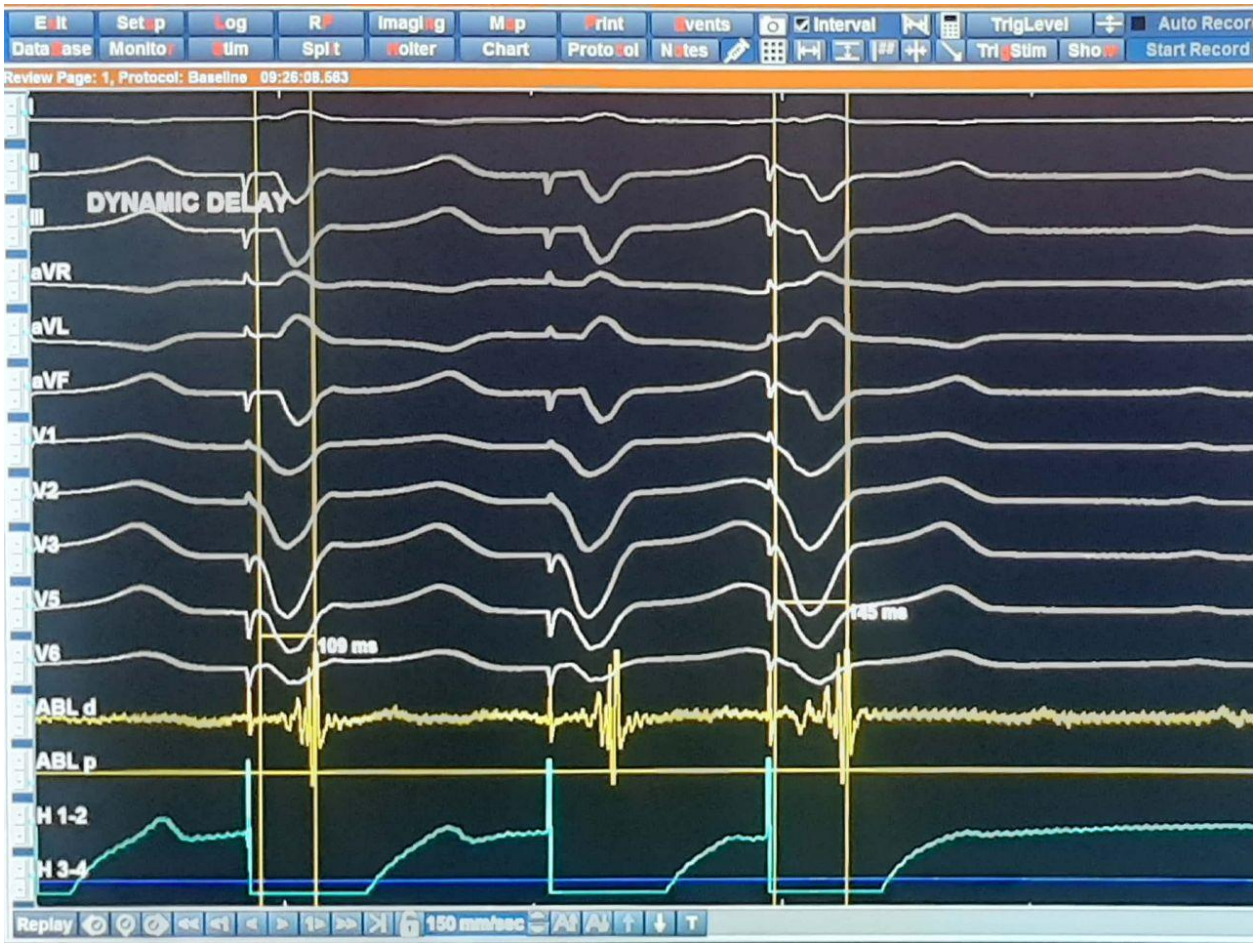

Figure (1): Intracardiac electrogram of a patient with arrhythmogenic right ventricular cardiomyopathy during right ventricular S1-S2 pacing. The late component of the paced QRS on the distal pole of ablation catheter shows significant delay with extrastimulation denoting a DEEP

Ablation was performed by ThermoCool SF™ catheter (Biosense Webster), ThermoCool ST™ catheter (Biosense Webster), FlexAbility ™ (Abbott) or TactiCath™ (Abbott). Concerning the DEEP group, ablation was initially restricted to points with DEEPs, while in the non-DEEP group, ablation aimed at elimination of all LPs. Acute success was defined as VT non-inducibility, including both clinical and non-clinical tachycardias. If VT was still inducible after ablation, activation and entrainment mapping were performed for hemodynamically-tolerated tachycardias, aiming at identification of the critical components of the re-entrant circuit -according to previously defined criteria (Brunckhorst *et al.*, 2004)(Stevenson *et al.*, 1997),

followed by ablation at such locations. If the VT was untolerated, pacemapping was performed aiming at a > 96% match (Bogun *et al.*, 2006)**.**

J. Follow up:

The study population was followed up for a mean duration of 12 months for the occurrence of the study endpoints. The primary endpoint was VT recurrence rates. Secondary endpoints were all-cause mortality and cardiovascular mortality. For patients with implanted defibrillators, follow up was done by interrogation of device recordings, while when defibrillators were not implanted, follow up was by history taking for the occurrence of symptoms or need for emergency department admission attributed to recurrence of VT.

K. Statistical analysis:

Continuous variables with normal distribution are presented as mean ± standard deviation and range whilst those with non-normal distribution are reported as median and interquartile range (IQR). Continuous variables were compared by Student's t-test, while categorical variables were compared by chi-square tests, or Fisher's exact tests as appropriate. Statistical analysis were performed using SPSS 25 for Windows (SPSS Inc, Chicago, Illinois, USA).