Automated template matching correlates with earliest activation during mapping of idiopathic premature ventricular contractions ☆

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ABSTRACT

Background: Ablation of premature ventricular contractions (PVC) can be challenging due to infrequent spontaneous ectopy and the limitations subjective pacemapping (PM). Activation mapping (AM) provides an objective parameter, but relies on spontaneous ectopic activity.
Objectives: The objective of the study was to evaluate the correlation of automated template matching (TM) with activation timing and to investigate potential implications towards ablation success.
Methods: Forty patients undergoing catheter ablation of idiopathic outflow tract VT or PVC in 47 procedures were included. PVC/VT origin was determined by PM and AM. A percentage value for PM was calculated using TM software and correlated with corresponding activation timing. Overall, 126 TM and corresponding AM values were analyzed. All patients were followed (313 ± 158 days after ablation) including a 24-hour Holter ECG.
Results: A correlation between TM and activation timing ($r = 0.66$, $P < 0.0001$) could be shown. Success rate at followup was 77%. No statistically significant coherence of TM percentage and relapse was observed.
Conclusions: Template matching correlates with activation timing in the process of mapping idiopathic focal PVC/VT. TM helps to objectify the process of PM and may therefore be helpful to guide successful ablation in the absence of spontaneous ectopy.

1. Introduction

Premature ventricular contractions (PVC) or idiopathic ventricular tachycardia (VT) in the otherwise healthy heart is not associated with increased mortality in the absence of a short coupling interval or a compromised left ventricular function and does not require treatment if asymptomatic [1]. Symptomatic PVC or VT on the other hand can burden patients with recurring palpitations, dizziness, dyspnea and possibly syncope in cases of fast VT. A reversible decrease in left ventricular function has been reported even in patients with no underlying cardiomyopathy [2]. Radiofrequency ablation (RFA) is a well-established method to treat idiopathic PVC and VT, and is associated with satisfying long-term results [3]. Determination of the ideal ablation site during the

electrophysiological study is commonly achieved by PM and AM. However, AM depends on frequent spontaneous PVC/VT during the electrophysiological study. In case of infrequent spontaneous activity it is common practice to administer isoproterenol to facilitate spontaneous ectopic activity, which has been shown to potentially alter the accuracy of AM [4]. An automated waveform comparison algorithm is implemented in the Bard® LabSystem™ PRO software (C.R. Bard, Inc. Lowell, MA), allowing fast online matching during electrophysiological study. Yet, correlation of this automated quantitative comparison of paced and spontaneous morphology and corresponding activation timing has not been studied. In addition, followup of patients to evaluate success of ablation and a possible correlation with template matching percentage has not been looked into so far. The purpose of this study was to investigate a possible correlation between 1) the automated template matching percentage and the activation timing during spontaneous PVC/VT, as well as between 2) the automated template matching percentage and the acute and late outcomes after ablation.

2. Material and methods

A retrospective analysis of 47 procedures of 40 consecutive patients undergoing catheter ablation for idiopathic VT or PVC from the right or

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left ventricular outflow tract at our Institution between March of 2009 and May of 2010 was undertaken.

2.1. Electrophysiological study and radiofrequency ablation

Electrophysiological study (EP) was performed in the fasting state and under sedation with propofol, after informed written consent was obtained. All patients had discontinued betablocker and antiarrhythmic medication for at least five half-lives and for feasibility reasons only patients with frequent PVC at the time of EP study were included. The source of ectopy was determined by both AM and conventional PM (1 mV above pacing threshold at 1.0 ms pulse duration). PM and AM were assessed for each catheter site if sufficient spontaneous PVC were present, before the catheter was moved to the next mapping site. PM was performed at a pacing cycle length within ± 100 ms of the coupling interval of the clinical PVC or at the same cycle length as the clinical VT [5]. Irrigated RF energy was delivered with a maximum power of 38 W for up to 180 s. A 7 French deflectable catheter with a 3.5-mm distal electrode (Thermocool, Biosense-Webster, Diamond Bar, CA, USA) was used for mapping and ablation. Successful ablation site was determined as the catheter position in which delivery of RF energy resulted in cessation of the spontaneous VT/PVC without recurrence throughout a waiting period of 30 min. Unsuccessful ablation was defined as an RF delivery for >30 s at a suspected site of VT/PVC origin, after which spontaneous ectopy of the same morphology persisted with unaltered spontaneous activity.

2.2. Template matching

Activation timing was measured from the local electrogram to the onset of the QRS in the 12 lead ECG. When electrograms were not discrete a second investigator (AS) was consulted and a consensus found to provide the highest possible accuracy for activation timing measurements. Percentage matching of the pacemap was measured with the aforementioned TM software (Bard® LabSystem™ PRO). A template of the clinical ectopy (dominant morphology if more than one) was created manually by positioning calipers strictly adjacent to the QRS. Paced electrograms were also marked manually and subsequently analyzed by the software, using the normalized correlation coefficient (CORR), as described recently [6], calculating correlation for each lead and subsequent mean of all leads (example given in Fig. 1). A mean of three measured scores was calculated to minimize the effect of beat-to-beat variation, with the first paced beat excluded from analysis. For each matching score the activation timing at this catheter location was measured before a template matching score was acquired in order to blind the investigator at the time of activation timing measurement. Values were acquired at all successful and unsuccessful ablation sites. Additional values were acquired during the process of PM, at sites where no RF energy was delivered.

2.3. Follow-up

We evaluated subjective ablation success and current medication by standardized questionnaire in person or via telephone after the ablation. Palpitation symptoms were assessed by questionnaire, from: "worse", "equal" or "better than before ablation", to "no more symptoms". Patients were asked to submit a 24-hour Holter ECG, recorded at least 3 weeks after the ablation. Ablation success was defined as freedom from or significant reduction of symptoms with PVC burden of less than 2% during follow-up. Successful VT ablation was defined as freedom from VT and its symptoms.

2.4. Statistical analysis

Continuous variables are expressed as means ± 1 standard deviation. Assuming a linear correlation, Pearson's correlation coefficient was used to analyze the relationship of template matching and activation timing. Student's t-test was utilized to compare continuous variables.

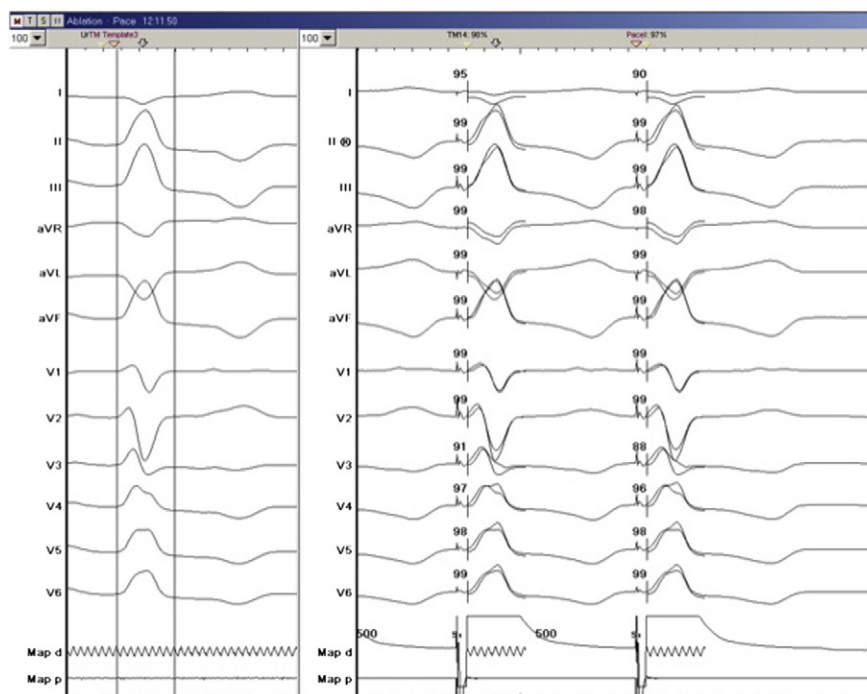A P-value (2-sided) < 0.05 was considered statistically significant.

Fig. 1. Representative example of template matching scoring. Selected template of the clinical ectopy on the left, with two of the three evaluated pacemap beats on the right side showing a correlation of 98% and 97%.