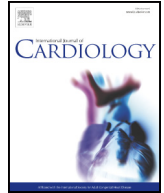




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Editorial

Activation-repolarization mapping to guide VT-ablation without the need to induce the arrhythmia

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Ventricular tachycardia and fibrillation are a major cause of sudden cardiac death, especially in the setting of chronic myocardial infarction (MI) [1]. These arrhythmias are mostly based on re-entry [1] and depend on the combination of a trigger (usually a critically timed premature activation) and an arrhythmogenic substrate. Surviving myocardial bundles that penetrate the scar tissue form the substrate and are the basis for a long activation delays across the myocardial scar. [2] The site(s) where the wavefronts exit from the scar can be targeted by ablation therapy. These exit sites can be identified during activation mapping by the characteristic ('focal') morphology of the local electrograms. For this approach the presence of the arrhythmia is a prerequisite. However, during the ablation procedure the arrhythmia often cannot be induced (the patient is sedated). Even if an arrhythmia can be induced, it may not be the clinically relevant arrhythmia, it may be not tolerated hemodynamically or it may be polymorphic. In the latter case, simultaneous (non-contact) activation mapping techniques can be applied to map the exit site(s) of the arrhythmia. If an arrhythmia cannot be induced the ablation is often guided by anatomical mapping of the substrate (scar) as a surrogate for functional mapping. It is conceivable that this approach leads to more ablation damage than strictly necessary.

The initiation and maintenance of re-entrant arrhythmias are caused by a critical interaction between the front and back of the activation wave [3]. The mathematical product of the conduction velocity and the refractory period (or action potential duration) constitutes the wavelength. If it is short enough to fit in a heart, the conditions favor re-entry. However, this is not the only precondition. The initiating impulse should encounter activation block, travel around it and re-enter the site of origin (unidirectional block) [4]. This condition is only met

if a critical relation exists between the repolarization time of the premature activation (RT_{S2}) at the origin (proximal) and the activation time of the premature activation (AT_{S2}) in the return pathway (distal). This is envisaged in Fig. 8 of our paper [4] and is reproduced in the paper by Martin and Orini et al. in this issue of the IJC [5]. The difference between the two values AT_{S2} and RT_{S2} has been termed the fibrillation factor (FF), or re-entry vulnerability index (RVI). In retrospect, these names are ill chosen, because an increased risk of re-entry occurs with a lower value. However, this does not detract from the fact that this measure has been shown to reliably identify the prospective 'exit' site(s) of the re-entrant arrhythmia under various conditions [6]. What is more, the FF or RVI can be measured just by eliciting a single premature activation and there is no need to induce the arrhythmia. In addition, the method will identify all potential exit sites, and not merely the one that is underlying the clinical re-entrant pathway. Ablation of only this primary exit site may unmask secondary exit site(s), and so on.

The concept that a steep restitution facilitates re-entry is also supported by the concept underlying the FF/RVI. The shorter the premature action potential is, the easier it will be for the re-entrant activation to re-excite the proximal tissue (see Fig. 1 of [5]). This relation was noted by Garfinkel et al., who explained it by the maximum steepness of the restitution relation (the 'cobweb' relation). He reasoned that, if the maximum steepness is >1 , alternation of action potential duration and subsequently re-entry followed [7]. However, Taggart et al. have shown that even in arrhythmic hearts from patients undergoing cardiac surgery the maximum slope of the restitution relation was below 1 in most of the sites sampled [8]. The RVI metric shows that it is not required to have a slope > 1 . The action potential shortening by premature stimulation should merely be sufficient (but not necessarily with a restitution slope > 1) to allow time for the re-entrant wavefront to reach the site of origin.

Martin and Orini et al. have combined measurement of the RVI (or FF) and activation mapping to patients with arrhythmias based on a structurally altered heart not caused by MI. The alterations involve increased fibrofatty replacement in the RV free wall (in patients with Arrhythmogenic Cardiomyopathy (AC)) [9] and subtle fibrosis in the RVOT (in patients with Brugada Syndrome (BrS)) [10]. In these hereditary syndromes re-entrant arrhythmias predominate and may lead to sudden cardiac death in relatively young patients.

The paper by Martin and Orini et al. carries important messages. First, it validates FF or RVI-mapping also in the setting of cardiac diseases with mild structural abnormalities [10]. Second, it shows that

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the minimum RVI in a patient also can predict the susceptibility to re-entrant arrhythmias on the longer term in individual patients. Therefore, a relatively high RVI identifies patients that do not have the substrate required for re-entry.

Thus, the authors have demonstrated that the RVI (FF) metric is able to differentiate between arrhythmogenic mechanisms. The patients with focal arrhythmias and those in whom the arrhythmia is not inducible, have higher values of RVI (FF) than patients with inducible arrhythmias (Fig. 3). It predicts long term risk for re-entrant arrhythmias in AC and BrS populations. Successful antiarrhythmic (ablative, genetic, pharmacological or otherwise) therapy should (instantaneously) increase the RVI (FF) to normal values. Mapping the RVI/FF, therefore, allows instantaneous evaluation of therapy success, without the need for inducing the arrhythmia or for applying aggressive induction protocols.

Conflict of interest

The authors report no relationships that could be construed as a conflict of interest.

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