Editorial

Interventional Cardiology

Evolution of AF ablation strategies-Role of PVI?

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Introduction

Atrial fibrillation (AF) is the most common clinical arrhythmia and its prevalence in the United States is expected to reach 6-12 million by the year 2050 [1]. A few decades ago, it was believed that AF was caused by a set of random and disorganized activations in the atria. Moe et al. [2,3] in 1964 first proposed his 'multiple wavelet hypothesis' according to which, new wavelets form after the initial wave break resulting in the multiple wavelet fibrillation. These wavelets are short lived and can either disintegrate after colliding with another wavelet or a non-conducting boundary, or fractionate in to multiple daughter wavelets. The second hypothesis put forward by Lewis in 1925 [4] and then by Gurvich in 1975 was the 'mother rotor hypothesis,' in which AF is maintained by a single rapid reentrant circuit of excitation [5]. This theory has been studied in detail by Jalife's group in large animal models and simulations, as the predominant mechanism for AF [6,7]. These two proposed mechanisms have been shown to appear in isolation and also simultaneously, resulting in a much more complex pattern of AF [8]. More recently in 2010, Allessie proposed 'the double layer hypothesis' adding a third dimension to the complexity of AF in which endo-epicardial dissociation plays a major role in maintaining AF [9,10].

In a majority of the AF cases, antiarrhythmic drugs are not effective and hence catheter ablation has become main line of therapy in certain subgroups of patients. Several studies have demonstrated various multiple ablation strategies with limited efficacy. Pulmonary vein isolation (PVI) has proven to be efficacious for paroxysmal AF, but its efficacy in persistent AF remains low [11]. In 1998, Haïssaguerre et al. [12] in his seminal paper showed that pulmonary veins (PV) triggers are critical for the initiation of AF and PVI can suppress occurrence of AF. In this study, 94% of the ectopic triggers originated from PVs resulted in AF. These observations made PVI the cornerstone in the invasive treatment of AF and was quickly adapted by the electrophysiologists around the world and became the preferred ablation strategy [13,14]. However, long term follow up after ablation, showed higher recurrence rates of AF especially in patients with persistent AF with success rates as low as 30% in the 3-5 year follow up [15,16]. These meager successes have shifted the focus on elucidating the mechanisms in which AF occurs and perpetuates despite PVI and how operators can target atrial substrates for a successful ablation.

Nademanee et al. [17] in 2004, introduced the concept of ablating complex fractionated atrial electrograms (CFAE). This approach restored sinus rhythm in 95% of the cases at 12 months follow up. However, the success rate was limited on a large scale due to the complexity of mapping fractionated electrograms which may be highly operator dependent and the results were not reproducible [18]. In 2012, Narayan et al. [19] introduced clinically a new method to identify and ablate AF sources which were thought to be the source of rotational activity in the heart that caused AF. Haïssaguerre et al. [20] published similar results in 2014. As various and combinations of ablation strategies increased success rates, performing solely PVI for AF ablation has remained a topic of debate. Recent multicentre randomized study (STAR AF II) [21] showed that PVI alone is sufficient in AF ablation and that additional lines may decrease long term success. However, peri-procedural AF termination was low in the group where only PVI was performed. Recently, Seitz et al. [22] showed there was increased effectiveness of AF ablation by targeting electrogram spatio-temporal dispersion sites and compared to the validation set in which patients underwent conventional PVI for paroxysmal AF and PVI+additional line and fractionated electrogram ablation for

persistent AF: 18 month follow up showed increased success rate in these patients as compared to the validation set (95% vs 63%). These results demonstrated that spatiotemporal dispersion of electrograms is the main source of AF drivers and that a patient specific ablation strategy targeting dispersion only can be used. This leaves the pulmonary veins intact and thus decreasing the potential complications from PVI such as PV stenosis. Jadidi et al. [23] confirmed this approach of spatio-temporal dispersion ablation in their recently published article.

Multiple studies showed that pulmonary vein triggers are not the only mechanisms responsible for AF. PVI alone is not enough in these patients and several studies have shown improved outcome with additional substrate ablation such as ablating ganglion plexi [24], ligament of Marshall ablation [25], CFAE [17], focal impulse or rotor modulation (FIRM) [19], dominant frequency ablation [26], and more recently 'Substrate Ablation Guided by High Density Mapping in Atrial Fibrillation (SUBSTRATE HD)' [22]. There is an evolution of new ablation strategies as we further understand the mechanisms of the AF initiation and perpetuation. These new approaches of ablation demonstrate superiority of substrate based ablation over PVI, especially in patients with persistent AF. Though the results are encouraging, more randomized studies are needed to validate these recent developments in the ablation field.

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