Selective Versus Total Pulmonary Vein Isolation In Atrial Fibrillation Ablation

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Abstract
One of the great discoveries in cardiac electrophysiology was the recognition of the crucial role of pulmonary vein (PV) myocardial sleeves for the initiation of atrial fibrillation (AF). Based on this concept, catheter ablation aiming at electrical isolation of all pulmonary veins has become the routine approach for paroxysmal AF. Another concept implies selective isolation only of arrhythmogenic PVs. Based on the most important studies dealing with both approaches, we describe pros and cons of selective compared to complete pulmonary vein isolation (PVI) and illustrate why selective PVI has not found widespread acceptance in the electrophysiologic community.

Introduction
The recognition of the crucial role of pulmonary vein (PV) myocardial sleeves for the initiation of atrial fibrillation (AF) is regarded as one of the greatest discoveries of the last decades in cardiac electrophysiology. Many ablation strategies are based on this concept and the initial punctual approach progressed to more extensive ablation. Overall, pulmonary vein isolation (PVI) has become a cornerstone of AF ablation. Experimental studies had demonstrated the electrophysiological properties of PVs. PVs possess a substrate for microreentry, which was shown by extrastimulus testing. The proximal PV has a significantly slower conduction compared to the rest of the left atrium (LA) with decremental conduction and variable entrance block observed at faster atrial pacing rates. Focal discharge in proximity to the area of slow conduction is also present with isoproterenol. Clinical studies demonstrated the distinctive properties of arrhythmogenic PVs. Selective identification and isolation of the arrhythmogenic PVs might therefore be preferable to a systematic complete PVI. However, due to several factors which we will discuss below, selective PVI has not become the routine approach for AF ablation.

Does Selective PVI Achieve A Similar Outcome Compared To Complete PVI?
Table 1 shows the results of the 3 randomized trials comparing isolation of arrhythmogenic vs. all PVs. Arrhythmia freedom at 12 months without antiarrhythmic drugs (AAD) after a single procedure was achieved in 53–62% by selective isolation of the arrhythmogenic vein(s) and in 59–74% by PVI of all veins. The slightly different results might be explained by different ablation approaches (segmental vs. circumferential PVI, irrigated vs. non irrigated tip catheter). The tendency towards higher success rates with complete PVI did not reach statistical significance in any of the 3 studies, perhaps due to small patient number or short follow-up.

What Are The Benefits Of Selective PVI?
Selective PVI potentially saves procedure duration, fluoroscopy duration, radiofrequency (RF) energy and thereby diminishes complications. However, a lower procedural duration was demonstrated in only one of the 3 randomized trials; procedure duration in this study appears to be long in both groups (186.7 ± 78.7 min. vs. 325.8 ± 107.6 min., p<0.01). A significant reduction in fluoroscopy and RF time was achieved in 2 studies (table 1), which is relevant for both patient and operator. None of the studies was powered enough to show a difference in complication rate.

What Are The Flaws Of Selective PVI?
Different And Laborious Protocols To Define The Arrhythmogenic PV
Most of the studies use laborious protocols to identify arrhythmogenic veins. Mapping of spontaneous atrial premature contraction (APC) can be accurate if these are repetitive and monomorphic. However, as in the study of Haisaguerre et al., spontaneous ectopy is often absent and AF duration variable. Thus, in the majority of cases provocative maneuvers including atrial bursts, isoproterenol infusion, adenosine triphosphate disodium injection, carotid sinus massage, Valsalva maneuver or even administration of effervescent agents or smoking were necessary to induce AF. Cardioversion of pacing-induced AF followed by observation of spontaneous arrhythmias was also used. In the study of Pak et
Programmed stimulation with a single extrastimulus (± orciprenaline) from inside each PV

- Spontaneous or pacing-induced AF or atrial runs from distally inside the PV.
- PV with the most pronounced decremental conduction properties at the PV-LA junction. (97%)

2.1±1.0
152.3±57.1 vs. 162±68.9 (p=n.s.)
27.7±14.2 vs. 33.5±19.5 (p=0.016)
33.9±22.9 vs. 47.6±21.1 (p=0.001)
53% vs. 59% (p=0.51)

Results of the 3 randomized trials comparing isolation of arrhythmogenic vs. all PVs

Patients
85±33 vs. 97±36 (p=n.s.)
20±10 vs. 17±9
61% vs. 59% (p=n.s.)
105

Isoproterenol infusion and AF induction by LA or RA burst pacing

- PV documented to initiate AF and/or atrial premature complexes based on direct intracardiac recordings and/or activation sequences of multipolar catheters located in the posterior right atrium and coronary sinus mimicking PV pace maps (98%)

Brief ischemia of the reinitiating PAC

1.5±0.6
186.7±78.7 vs. 325.8±107.6 (p<0.01)
54.1±17.6 vs. 97±31.1 (p=0.01)
51.0±16.4 min. vs. 127.2±60.3 (p<0.01)
62% vs. 74% (p=0.05)

Pak et al. 2008

- Sustained AF induced by high rate right atrial burst stimulation, if necessary with isoproterenol administration.
- After internal cardioversion mapping of the reinitiating PAC

In this study, very late recurrence occurred more often in the selective PVI group (19% vs. 5.7%). During the reablation procedure, only 53.8% of the arrhythmogenic foci were at previously ablated PVs, suggesting that “new” veins were now arrhythmogenic. In the study of Dixit et al., triggers identified from reconnected PVs during redo procedures were demonstrated in 74% of patients.

Conclusion:
Selective isolation of arrhythmogenic PVs has not been established as a routine approach for paroxysmal AF ablation. This is mainly due to methodological problems to identify the arrhythmogenic vein and evidence that PV arrhythmogeneity is not a static feature but might vary under the influence of the autonomic nervous system. As complete PVI has become a routine procedure with low complication rates, a systematical isolation of all PVs is usually warranted. However, in selected young patients with a single triggering PV focus, selective PVI represents an elegant and effective approach.

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