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Selective Versus Total Pulmonary Vein Isolation In Atrial Fibrillation Ablation

Sonia Ammar, MD, Tilko Reents, MD, Stephanie Fichtner, MD[1], Gabriele Hessling, MD, Isabel Deisenhofer, MD

Department of Electrophysiology, German Heart Center Munich, Technical University Munich, Germany. [1]Department of Medicine I, University Hospital Grosshadern, Ludwig-Maximilians-University, Munich, Germany.

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 of 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) initiation is regarded as one of the greatest discoveries of the last decades in cardiac electrophysiology.[1,2,3] Many ablation strategies are based on this concept and the initial punctual approach progressed to more extensive ablation.[4-8] Overall, pulmonary vein isolation (PVI) has become a cornerstone of AF ablation.

Experimental studies had demonstrated the electrophysiological properties of PVs.[9] 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.[10] 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.[11-13] 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;[12] 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[11,12] (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.,[14] 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.[8] Cardioversion of pacing-induced AF followed by observation of spontaneous arrhythmias was also used.[15] In the study of Pak et

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Corresponding Author:
Sonia Ammar, MD,
Deutsches Herzzentrum München,
Lazarettstrasse 36,
D-80636 Munich, Germany.

Table 1: Results of the 3 randomized trials comparing isolation of arrhythmogenic vs. all PVs

Study	Patients (n)	Provocative manoeuver	Definition of arrhythmogenic vein (Possible selection, %)	Number of arrhythmo-genic veins	Procedure time (min.)	Fluoroscopy time (min.)	RF applications/ RF time	Freedom from arrhythmia recurrence after a single ablation off AAD (%)
Fichtner et al. 2012[11]	207	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).
Pak et al. 2008[12]	77	- Sustained AF induced by high-rate right atrial burst stimulation, if necessary with isoproterenol administration. - After internal cardioversion mapping of the reinitiating APC	Reinitiation of AF from the same PV at least three times (33%)	1.5±0.6	186.7±78.7 vs. 325.8±107.6 (p<0.01)	54.0±17.6 vs. 97.5±31.1 (p<0.01)	51.0 ± 16.4 min. vs. 127.2 ± 60.3 (p<0.01)	62% vs. 74% (p=n.s)
Dixit et al. 2007[13]	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 RA and coronary sinus mimicking PV pace maps (98%)	2.9 ± 0.9	317±88 vs. 327±93 (p=n.s)	85±33 vs. 97±36 (p= ns.)	20±10 vs. 17±9	61% vs. 59% (p=n.s)

RF: radiofrequency, AAD: antiarrhythmic drugs, PV: pulmonary vein, AF: atrial fibrillation, LA: left atrium, RA: right atrium, APC: atrial premature beat, min.: minutes

al.[12] a PV was defined as arrhythmogenic if AF reinitiation after cardioversion occurred from the same PV at least 3 times. With this protocol, arrhythmogenic veins were defined in only 33% of the population. Dixit et al.[13] found arrhythmogenic PVs in 98% of patients based on direct intracardiac recordings and/or activation sequences of multipolar catheters located in the posterior right atrium and coronary sinus. This difference shows that catheter placement for PV mapping and definition of arrhythmogenitiy vary widely among operators. Jais et al.[4] demonstrated that PVs in AF patients have distinctive electrophysiological properties consisting of short effective refractory periods (ERP) with decremental and slow conduction. In this study, AF was preferentially induced after a single extrastimulus from the vein suggesting that inducibility depends on proximity to critical areas (with short ERP and long conduction time) such as PVs. Based on these findings, Fichtner et al.[11] developed a simple and reproducible protocol for selection of arrhythmogenic PVs. Programmed stimulation with a single extrastimulus (if necessary with orciprenaline) was performed from inside each vein and showed a high rate of AF induction (78%) or PV triggers (7%). If AF was not induced, the PV with the most pronounced decremental conduction properties at the PV-LA junction was considered arrhythmogenic (15%). Following this protocol, arrhythmogenic veins were identified in 97% of patients.

Development Of "New" Arrhythmogenic PVs During Follow-Up

The main concern regarding ablation of arrhythmogenic PVs is the status of the autonomic nervous system which might differ between the electrophysiological study and "real life". PVs demonstrated to be non- arrhythmogenic might become arrhythmogenic and vice versa. This is supported by the findings of the study of Pak et al.[12] 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.[13] triggers identified from reconnected PVs during redo procedures were demonstrated in 74% of patients.

Which Patients Might Benefit From Selective PVI ?

Haisaguerre et al.[14] demonstrated that the prevalence of multiple arrhythmogenic PVs was high (69%) and associated with older age, longer AF duration, and larger atrial dimensions. In the retrospective study of Gerstenfeld et al,[15] patients with ≤2 arrhythmogenic PVs had similar results than patients with ≥3 arrhythmogenic PVs (58% vs. 65%, p= n.s). However, patients younger than 50 years undergoing isolation of ≤2 PVs had the best outcome (73%). In the study of Fichtner et al.[11] a tendency toward a better outcome was shown in patients with only one arrhythmogenic PV (63% vs. 59%, p= 0.12). Young patients with clearly only one firing PV (even spontaneous or after provocation) appear to be the best target group for selective PVI. However, knowing the high rate of electrical connections between contiguous PVs, ipsilateral PVI might be required.[16] One non randomized study showed similar results between ipsilateral and bilateral PVI of focal PV triggered paroxysmal AF.[17] In the subgroup of patients aged ≥50 years with an LA diameter ≥40 mm, ipsilateral PVI appeared to be insufficient with AF freedom achieved in only 17% vs. 65% after bilateral PVI.

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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