

Catheter ablation of atrial fibrillation: recent advances and future challenges

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Over the last three decades, catheter ablation has evolved to a highly effective treatment strategy for rhythm control in atrial fibrillation (AF) patients. Indeed, it has been almost 30 years since the pioneering the first application of AF catheter ablation by Swartz *et al.*¹ Swartz was stimulated by the surgical approaches for the treatment of AF introduced by Cox *et al.*² and tried a catheter-based replication of the surgical lesion set. Subsequently, Haissaguerre *et al.*³ introduced the ground-breaking concept of 'focal' AF with the identification of focal sources from the pulmonary veins that induce AF. This finding introduced the treatment strategy of pulmonary vein isolation for the effective ablation of AF by radiofrequency (RF) catheter ablation. The strategy was further developed by the introduction of three-dimensional mapping technologies by Pappone *et al.*⁴ and Karl-Heinz Kuck.⁵ The so-called circumferential pulmonary vein ablation technique established a standard for percutaneous treatment of fibrillation ablation. In parallel, single-shot ablation technologies with balloon-based cryoablation were introduced and also proved excellent treatment results.⁶ In the early 2000s, the first convincing randomized clinical trials comparing catheter ablation with antiarrhythmic drug therapy for rhythm control proved the superiority of the ablation approach. In later years, landmark clinical trials such as Star AF,⁷ Cabana,⁸ Fire and Ice,⁹ and Castle AF¹⁰ supported the strong role of catheter ablation for

rhythm control for patients with AF. Recently, clinical trials proved the benefits of early rhythm control with antiarrhythmic drugs and catheter ablation.¹¹ Moreover, substantial technical and technological advances have been introduced to further develop catheter ablation of AF as the standard therapy for AF rhythm control. With this supplement, we would like to highlight these new findings and evidence and put them into the perspective of contemporary catheter ablation application. International experts and key opinion leaders from the field of catheter ablation contributed with superb manuscripts on the important aspects of AF catheter ablation to the supplement.

The progression of AF from rare and short-lasting episodes to persistent forms of AF is a characteristic development in most patients affected. However, the dynamics of such progression may be quite different for individuals with AF. While some patients may progress rapidly, others remain with short lasting and/or rare episodes for many years. However, for almost all patients with AF, there is a general trend to AF progression. It is currently not fully understood which drivers modulate the progression of AF and whether the drivers the same or at least similar in most patients or whether individual factors may play a key role. In addition, whether AF itself promotes the progression ('AF begets AF') is unclear. All this raises the question if early ablation of AF may be feasible to decelerate or even stop the progression of AF. Willems and colleagues focus in their contribution on this topic and provide a state-of-the-art overview on current knowledge and perspective, particularly in the light of the opportunities with early rhythm control in AF patients.

The leading role of pulmonary vein isolation as the main treatment strategy for catheter ablation has already been mentioned. Metzner and colleagues summarize the techniques and technologies that have been developed to achieve complete and hopefully also durable isolation of the pulmonary veins. The durability of induced lesions seems to be crucial for the long-term success of the procedure. Novel strategies and technologies that have been developed are presented and discussed. Furthermore, the role of additional extrapulmonary ablation strategies is discussed.

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What are the clinically relevant end points and outcome measures after catheter ablation of AF? With respect to rhythm outcome, the '30 second rule' was the standard to define the success of the ablation procedure. However, is a single documented 2-min recurrence of AF after an ablation procedure really a good marker for the definition of procedure success or failure? This is at least debateable and Blomstrom-Lundqvist and colleagues discuss in depth and pros and cons of various treatment end points. In their article, the authors also introduce the concept of health-related quality of life research for the development of better treatment end points and improved grading of ablation treatment efficiency and safety. The evolving role of patient-reported outcomes and is explored and presented as evident from recent clinical research. The role of traditional rhythm-based outcome measures depending solely on the presence or absence of electrocardiogram-documented recurrence of AF is substantially questioned and the authors suggest and promote a more patient-centred outcome evaluation.

In 2012, the Mantra paroxysmal atrial fibrillation (PAF) randomized clinical trial documented for the first time the superiority of AF catheter ablation over medical antiarrhythmic drugs treatment for rhythm control as the first-line treatment for patients with AF.¹² Subsequent clinical trials supported the findings of Mantra PAF. Until recently, it was unclear whether comparable benefits can be achieved with balloon-based cryoablation. Andrade and colleagues summarize in their contribution the results of recent randomized trials with cryoablation as first-line therapy for rhythm control in AF patients. Indeed, it seems that the first-line cryoablation results in the same benefits that have been previously shown for RF catheter ablation. These new trial results are put into a practical clinical perspective to guide ablation indications and therapies with AF cryoablation.

The technological and technical improvements of catheter ablation achieved over the years are highly impressive. The continuous implementation of new technologies has certainly contributed to make the ablation procedure faster, more effective, and most importantly also safer. Within the last 2 years, additional improvements have been reported with novel RF catheter designs and modes of RF-energy application. The same is true for the field of cryoablation with the availability of new balloon technology. The most important innovation, however, may be the introduction of pulsed-field ablation technology. This energy source is almost exclusively based on direct electrical-induced tissue damage without the significant contribution of thermal or barotraumatic-traumatic effects and seems to offer faster and safer ablation treatment. Lucas Boersma introduces an amazing set of new technologies and describes the application and potential benefits for the further development of AF catheter ablation procedures.

In 2020, the European Society of Cardiology introduced new guidelines for the management of AF.¹³ With the introduction of the management pathway—A: anticoagulation/avoid stroke; B: better symptom control; C: co-morbidities/cardiovascular risk factors (ABC) management pathway and the idea of AF characterization with the 4S concept, the new guidelines added substantial new perspectives in the field of AF management. These perspectives as well as other novel recommendations are presented and discussed in the

manuscript from Elena Arbelo and Nikos Dagres. In addition, the authors present and discuss new evidences from very recent clinical trials that were not available during the writing process of the 2020 ESC guidelines. The authors address the interesting and important question of whether these new data should give lead to a new interpretation of the current guideline recommendations or may even be strong enough for a guideline modification.

Overall, we believe that the manuscripts included in the supplement of the *Europace* journal are a substantial contribution to the ongoing discussion on the role, relevance, and future perspective of catheter ablation for the treatment of AF. We would like to thank all authors for their excellent contributions and hope that all readers enjoy this state-of-the-supplement of *Europace*.

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