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INTRODUCTION

Commemorating twenty years since the first catheter-based pulmonary vein isolation to treat atrial fibrillation by ablation

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Surgical pulmonary vein isolation by ablation as a treatment for atrial fibrillation was first performed in isolation in 1996 at Hospital de Santa Cruz in Portugal, as a complementary therapy to mitral valve surgery in patients with rheumatic mitral valve disease, in order to reduce the morbidity associated with maze surgery.[1]

This innovative surgical approach, performed by Queiroz e Melo, replaced the maze technique's fragmentation of the atria using surgical incisions by application of radiofrequency energy along the pulmonary veins.[2] Its efficacy was assessed by electrophysiological studies that showed bilateral pulmonary vein isolation[3] and it reduced postoperative morbidity.

The surgical procedure reproduced a preliminary study in sheep by Fieguth et al., which showed that atrial fibrillation was not inducible following surgical isolation of the pulmonary veins.[4]

In 1996, having confirmed the efficacy of surgical isolation and the feasibility of reproducing the same effect via catheter, we performed the first percutaneous procedure, in a patient with mitral stenosis and atrial fibrillation, at Hospital de Santa Cruz (Appendix A. Supplementary data). This patient was indicated for balloon mitral valvuloplasty due to rheumatic mitral valve stenosis, and after valve dilatation, using the same transseptal route, we isolated the pulmonary veins.

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We then performed the same procedure in four more patients and presented the initial results at the 18th Portuguese Congress of Cardiology in April 1997[5] (Appendix A. Supplementary data) and in the Feature Session of the 18th Annual Scientific Sessions of the North American Society of Pacing and Electrophysiology in May of the same year.[6] (Appendix A. Supplementary data).

After five years of follow-up, two of the patients were in sinus rhythm, two in atrial fibrillation and one underwent ablation for atrial flutter four years after the first ablation. In the latter patient, the effectiveness of the previous isolation in eliminating solutions of continuity was demonstrated by three-dimensional mapping (CARTO and EnSite).[7]

After Pierre Jaïs had reported that episodes of atrial fibrillation had a focal origin and showed that these foci could be ablated, in 1998 Michel Haïssaguerre confirmed the importance of foci in the pulmonary veins.[8,9]

However, application of radiofrequency to foci in the pulmonary veins, as advocated by Haïssaguerre, was not without risk, and was accompanied by an unacceptably high incidence of pulmonary vein stenosis.[10] In 2000, it was confirmed that the only solution was to return to the strategy that we initially proposed, that of electrical isolation of the pulmonary veins,[11] and the 2012 HRS/EHRA/ECAS consensus statement on ablation of atrial fibrillation identified pulmonary vein isolation as the cornerstone for ablation treatment of atrial fibrillation.[12]

It was demonstrated that the particular characteristics of the pulmonary vein ostia, including their short refractory periods and close relationship with the autonomic nervous

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system,[13–15] explained their importance in the genesis and maintenance of atrial fibrillation.[16]

In view of the pandemic proportions of atrial fibrillation (2.5% of the population aged over 40 in Portugal),[17] the scene was set for this new treatment modality to be rolled out in the main centers for cardiac electrophysiology. At the same time, rapid advances in technology led to the development of three-dimensional mapping and ablation systems such as CARTO,[18] EnSite[19] and NavX,[20] which provided anatomical precision and enabled the safe creation of contiguous and spatially controlled lesions.

The work of Carlo Pappone[21] in three-dimensional mapping and the precise location of ablation lesions has played a major role in the development of modern electrophysiology; he has also been a pioneer of robotic systems.[22] However, as has happened with other important scientific breakthroughs, the electrophysiological community was unprepared to fully embrace the new technology.

Pulmonary vein isolation was shown to be ideal for patients with relatively undilated left atria, but was less effective in cases of atria that are enlarged or severely fibrosed.[23–25] Success rates in paroxysmal forms reach 70% but are considerably lower in persistent and long-standing persistent forms.[26]

There have accordingly been attempts to find alternative therapies, including radiofrequency application to complex fractionated atrial electrograms (CFAE)[27] and associating linear lesions in order to create an 'electrophysiological maze' effect.[28] Besides the pulmonary vein antrum, other areas have been the focus of attention, particularly the superior vena cava[29] and the atrial appendage.[30]

However, the apparent effectiveness of such interventions, which were intended to complement pulmonary vein isolation, was not confirmed by the randomized STAR AF II trial,[31] which compared pulmonary vein isolation alone, pulmonary vein isolation plus ablation of CFAEs, and pulmonary vein isolation plus additional linear ablation.

In acknowledgment of this result, the 2016 European Society of Cardiology guidelines for the management of atrial fibrillation[26] confirm pulmonary vein isolation as the treatment of choice for atrial fibrillation, even in persistent forms, and state that routine deployment of additional linear lesions or ablation of CFAEs has no additional benefit in the first procedure. The guidelines also indicate that single-application ablation techniques such as cryoablation have similar outcomes to point-by-point isolation, citing the results of the FIRE AND ICE trial.[32]

However, although pulmonary vein isolation alone appears to be accepted as the treatment of choice, long-term results indicate a success rate of only 50% in persistent atrial fibrillation. This figure is obviously unsatisfactory.

Pulmonary vein isolation for atrial fibrillation ablation is generally a safe procedure, with low morbidity and mortality (0.1%),[33] but it does have potential complications that must be prevented or controlled, such as phrenic nerve injury or atrioesophageal fistula.[34–37]

The quest for a definitive treatment of atrial fibrillation requires a kind of intellectual restlessness, constantly searching for new forms of dynamic mapping, such as four-dimensional imaging,[38] new ways to analyze electrograms (rotors and stable CFAEs),[39,40] new methods for applying energy to reduce reconduction,[41,42] and new therapeutic targets.[43–45]

No stone should be left unturned. We need new research paths to develop complementary or alternative therapies to pulmonary vein electrical isolation for the treatment of atrial fibrillation.

In this symposium, as we commemorate 20 years since the first pulmonary vein isolation, the main actors in the field will present and discuss new perspectives and strategies to understand and treat the fascinating puzzle that is atrial fibrillation.

Conflicts of interest

The author has no conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.repc.2017.09.013.

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