The multiple wavelet theory of Moe [1], later supported by animal studies [2], explaining that atrial fibrillation (AF) can only become established when more than a critical number of wavefronts coexist in the atrium, was a major step in our understanding of this complex and multifactorial disease. This concept is one of the cornerstones leading to the development of a successful antiarrhythmic approach to interrupt conduction in both atria, by creating a network of surgical lines, similar to a maze [3]. However, catheter-based maze procedures (in comparison with the surgical procedure), lacked efficacy and were associated with major complications such as stroke and pericardial effusion [4].

The treatment of atrial fibrillation entered a new era after the publication of the landmark observations of Haïssaguerre et al. [5]. The recognition of the role of myocardial extensions [6] within the pulmonary veins in initiating AF changed both pathophysiological insights and the therapeutic approach. For the first time it was expected that electrophysiologists could cure AF the way they could cure patients with accessory pathways, atrial flutter and AV nodal re-entrant tachycardias. As usual, the initial enthusiasm was followed by the awareness of limitations. Nevertheless, the approach of pulmonary vein (PV) ablation has stayed on the agenda.

**Myocardial sleeves**

It has been known for some years that the left atrial myocardium extends a few centimetres into the pulmonary veins [6]. Embryological studies explained their possible role in arrhythmogenesis [7]. While this might explain the pacemaker activity in these fibres, it is not clear why this ectopic activity triggers AF in a limited number of people ("what triggers the trigger?"). The paper in this issue by De Ponti and co-workers [8], showing that one third of the patients has this kind of ectopic activity in the PVs elegantly demonstrates the potential of high-density mapping using a multi-electrode basket catheter in clarifying conduction and breakthrough patterns. Longitudinal conduction in the PVs is helpful in understanding activation patterns and finding ablation sites [9]. Electrode systems such as the basket have therefore a role in helping us to understand the physiology of a PV, and are probably more helpful in this respect than semicircular or circular electrode catheters, which can only show one level of abnormal electrical activity.

**Success rate**

The long-term effect of PV ablation is not known despite the high initial success rates that have been reported [10,11]. It has become clear, however, that a high percentage of patients experience recurrences [12]. This raises questions about the value of the procedure. Overestimation of the possible results to be achieved is now replaced by redefined expected ablation endpoints. Complete isolation of all veins remains the best option—return of conduction will nevertheless occur in a certain number.

**Diagnostic issues**

Persistent triggering can be due to the existence of extrapulmonary vein foci (vena cava, left atrium). Better than hunting for ectopic activity might be segmental ostial catheter ablation [13] or left atrial encircling ablation of the PVs [10]. That methods to improve the ablative diagnostic approach exist is demonstrated by one paper in this issue, illustrating how inventively generally
available tools (Fig. 1) can be adapted to isolate pulmonary veins [14]. Intracardiac echocardiography is a more powerful diagnostic tool than pure navigation mapping, and can help to understand (normal or abnormal) anatomy and, moreover, has now been reported as a guide for RF ablation [15].

**Therapeutic options**

The best energy source for ablation is still a matter of debate; conventional radiofrequency is associated with serious complications [16]. The “How to...” paper by Gill, included in this issue, describes how to avoid such complications. The author uses a conventional energy source and is avoiding applications in the vein [17]. The irrigated tip probably causes less problems and is more effective [18]. New energy sources such as cryothermy [18,19] or ultrasound [20] are promising. New catheter systems should be developed to optimise therapy delivery [21]. The so-called “left isthmus line (from left inferior PV to mitral annulus)” may be an important addition to PV isolation.

**Complications**

Paralleled by the number of procedures, the knowledge of possible complications has increased. Known complications include pulmonary vein stenosis, thromboembolism, haemopericardium and damage to adjacent structures such as pulmonary artery, phrenic nerve and lung tissue. In this issue Schwab et al. describe the occurrence of temporary ST elevation and elevation of troponin readings [22]. They hypothesize that this resulted from catheter induced coronary spasm while moving in the dorsal part of the left atrium. However, such abnormalities are not uncommon [19].

Mansour and colleagues observed early formation of a left atrial clot using intracardiac echocardiography [23]. Their observations are important and support the policy of rapid and adequate anti-coagulation with heparin after (or before?) transseptal puncture. An anti-coagulation policy put forward in the Gill “How to...” article in this issue is one approach. However, this should be adapted to local habits and control, until more evidence-based data are available [17]. Transoesophageal echo is part of the protocol in some institutions, and can be helpful in preventing...
stroke [15]. The incidence of pulmonary vein stenosis is another important outcome variable and its development in long-term follow-up is not known. Comparison of the reported frequency of PV stenosis after ablation is difficult because of the different diagnostic modalities (angiography, CT and MRI) used. Its occurrence stimulates the search for alternative energy sources for ablation. In our and others experience [19,20], cryothermy ablation is promising in this respect.

Patient selection

Important is the selection of patients who will most likely profit from PV ablation [17]. Possibly, the need for different procedures depends on the relative importance of substrate and triggers in a given patient [24]. The improvement in quality of life found [12] in patients who were ablated but with recurrences of AF is not explained, but may result from altering left atrial innervation.

Future directions

Atrial fibrillation is an arrhythmia with a multifactorial aetiology. It is very unlikely that a single solution for all AF patients will be developed. The role of increasing fibrosis is probably of the utmost importance in the elderly, in patients with hypertension and in those with valvular heart disease. Therefore, attention should be directed towards drugs that prevent or diminish fibrosis and at ablation procedures targeting the substrate. For a subset of patients, PV ablation therapy, today, is a promising alternative to unsuccessful drug therapy. Investigational modalities of energy delivery seem to be important, in order to avoid complications. Further technological improvement such as a magnetic navigation system [25,26] can potentially be of help in mimicking the surgical maze procedure by a catheter-based approach, which should result in similar efficacy. One thing is evident: many strategic and practical questions need to be answered before this approach is to be considered an established therapy.

References


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