J Interv Card Electrophysiol (2006) 17:195–198
DOI 10.1007/s10840-007-9083-3

Mapping and ablation: A worldwide perspective

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Received: 23 November 2006 / Accepted: 24 January 2007 / Published online: 6 April 2007

Abstract Currently, many ablative techniques have reported excellent long-term results in restoring and maintaining sinus rhythm among patients with paroxysmal and persistent AF. Catheter ablation of AF should not be performed too late over time when recurrent paroxysmal AF progresses to the persistent or to the permanent form. Among patients with permanent AF, the stepwise approach requires very extensive lesions in both the left and right atrium to obtain the same success rate as reported by CPVA as performed in Milan many years ago. Long-term prospective multicenter randomized studies comparing the impact of medical therapy with catheter ablation strategy on "hard" outcomes such as morbidity and mortality are required to better define the patient population that may mostly benefit from ablation at the lowest risk and acceptable cost.

Keywords Cardiac mapping · Supraventricular tachycardia · Atrial fibrillation · Catheter ablation

In the last years, multiple techniques have been developed for mapping and ablation of atrial fibrillation (AF), all reporting excellent success rates particularly in patients with paroxysmal and persistent AF [1–8]. As a result, catheter ablation of AF is now widely practiced as a definitive treatment for AF. The current techniques focus on the elimination of different mechanisms, which are essentially represented by triggers (PV and non-PV foci) and substrate (autonomic and electrophysiologic), all of which are likely to be simultaneously encompassed by circumferential pulmonary vein ablation (CPVA) (Fig. 1). In agreement with our initial concerns, it has become evident that simple exclusion of pulmonary venous tissue (PV isolation), unlike CPVA, is ineffective in treating patients with long-lasting/permanent AF with or without associated diseases [6].

Considering that the highest success rates of catheter ablation have been reported worldwide for paroxysmal AF and less for long lasting/permanent AF which requires extensive lesions in both atria, it is necessary to emphasize the crucial role of the timing of the procedure. It is well-known that AF tends to become more persistent and then permanent, which at this stage, is more difficult to treat, presenting a major therapeutic challenge for both clinical cardiologists and electrophysiologists. To make matters worse, the incidence of AF is increasing as the mean age and the prevalence of heart failure in the general population increase worldwide; associated mortality rates of patients with AF are also on the rise. Therefore, in our opinion, catheter ablation of AF should not be performed too late over time when recurrent paroxysmal AF progresses to the persistent or permanent form. Long-term prospective follow-up studies are necessary to elucidate the progression time and associated risk factors within each form to identify patients at highest risk of progression for an early ablation strategy. It is reasonable to assume that in the near future, most patients will benefit from an appropriate timing of procedure contrasting a potential rapid progression to the permanent form, which may change both the natural history and prognosis of the disease.

The excellent long-term results of catheter ablation without significant risks reported worldwide in patients with paroxysmal AF and the introduction into clinical

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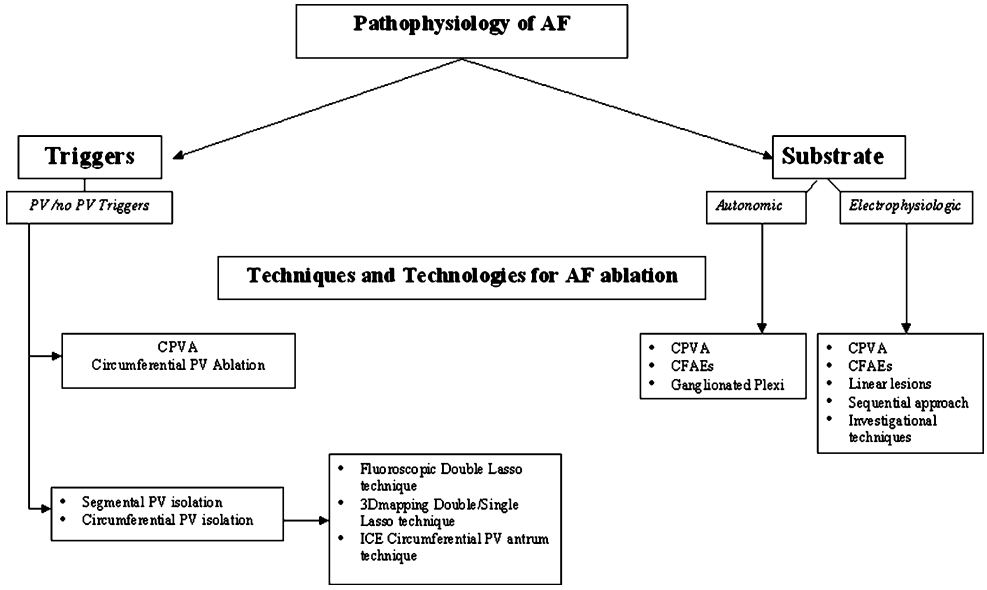

Fig. 1 Techniques and technologies for AF ablation

practice of several new tools and techniques have contributed to the expansion of inclusion criteria for catheter ablation of AF. Expanded indications at many centers now include patients with permanent AF and patients with congestive heart failure [9]. Recently, catheter ablation has been shown to improve left ventricular function and quality of life in patients with AF and congestive heart failure; despite success, definition has always been based on scientific endpoints, such as no recurrence [10]. Although recurrences of AF ranging from seconds to minutes have been considered in previous studies as failure, in our opinion, such binary outcome analysis is limited, as any clinical benefit to the patient would not be recognized. Indeed, we believe that in the future, success definition should also be based on clinical criteria if the magnitude of therapeutic impact of catheter ablation on patients' quality of life is significant. For a patient who is transformed from a predominant pattern of highly symptomatic long lasting AF with occasional spontaneous terminations preablation to a pattern of asymptomatic or symptomatic short-lived episodes of transient AF lasting even over a minute postablation, the procedure should be considered clinically successful.

AF ablation is effective in restoring sinus rhythm and improving the quality of life but with longer follow-up periods, and large-scale randomized trials are required to evaluate other important outcome endpoints such as long-term morbidity and potential benefit on mortality. It is also important to assess potential long-term benefits in older patients, with associated diseases such as heart failure, hypertension, coronary heart disease, and diabetes mellitus, who are at the highest risk. These patients would probably be the ones that would benefit the most from an early procedure when AF is still in its initial clinical form. On the other hand, many young patients without associated disease (lone AF), would not greatly benefit in terms of AF progression, morbidity, and mortality from an early ablation. Excellent success rates after catheter ablation for AF may be expected in younger paroxysmal AF patients with no structural heart disease, but likely overestimates success in older patients with persistent and chronic AF. Most investigators have reported outcome data for no more than 2–3 year follow-up after the procedure, leaving longer-term outcomes uncertain.

When choosing an invasive procedure, such as catheter ablation, in patients with AF, the physician should always take into account the benefit/risk ratio [10]. To minimize risks, new tools in the field of catheter ablation are being constantly developed for AF, which include, but are not limited, to new 3D mapping systems and their integration with three-dimensional magnetic resonance imaging (MRI) and computed tomography (CT) data sets, remote navigation and ablation systems, new catheters, and intracardiac echo. These tools are also expected to be a stepping stone to the ultimate goal of real-time anatomical guidance of catheter ablation and potential elimination of radiation exposure. This is also expected to be facilitated by mechanical (robotic) and remote catheter navigation [11]. It is still unknown whether shorter procedure times and more widespread applicability of catheter ablation techniques to AF treatment may be facilitated by the introduction of customized coil and balloon-based ablating elements using alternative energy sources such as cryothermy, laser, and ultrasound. These various balloon-based ablation technologies are being developed, but the next few years will provide more information regarding their safety and efficacy. This impressive and constant advance in technology may hopefully permit manipulation of catheters in an anatomically accurate three-dimensional environment, enhancing the ease and safety of the procedure.

Another important issue is the evaluation of cost effectiveness of catheter ablation of AF, also considering the relevant costs of several tools used in different strategies. It is important to stress that most such procedures utilize several catheters simultaneously, with the procedure guided by nonfluoroscopic imaging. Advanced mapping techniques significantly boost success of this procedure. Unfortunately, this comes with a hefty price tag with catheter ablation for AF, generally two to four times more expensive in equipment costs compared with ablation for other conditions. Efficacy should be evaluated taking into account not only long-term restoration of sinus rhythm and improvement of quality of life, but also potential morbidity and mortality benefit. Catheter ablation is a potentially cost-effective strategy in patients with AF, with the cost of this therapy approaching the cost of medical care around 5 years after the procedure. In the group in which catheter ablation is most commonly offered, that is, young patients at low risk of stroke, the cost effectiveness of atrial fibrillation ablation appears to be marginal. Unfortunately, at present, there are no conclusive data on long-term cost effectiveness of the different techniques and tools in patients with AF. While randomized data comparing efficacy of catheter ablation with that of medical therapy are limited, studies to date suggest a striking superiority of catheter ablation with respect to maintenance of sinus rhythm and quality of live measures [12–15]. There is only one observational study to date from our group, which suggests a correlation between successful catheter ablation for AF and "hard" clinical outcomes of morbidity and mortality [16]. CPVA was performed in 589 patients, with the remainder treated medically, aiming at rhythm control. At 900 days of follow-up, patients treated with ablation had a 70% reduction in the likelihood of atrial fibrillation recurrence. Ablation was associated with greater than 50% reduction in all cause mortality and in morbidity related to heart failure and embolic events. Kaplan–Meier survival of the ablated patients was substantially better than that of patients treated medically and approached survival in the general Italian population [16]. The results of this study also support withdrawal of anticoagulation in ablated patients, most of whom were young, with only about 30% of the patients having history of hypertension or structural heart disease, thus, representing a population at relatively low risk of embolic events. The vast majority had paroxysmal rather than persistent or chronic AF, and a few had significant left atrial enlargement.

The success rates approaching 100% first reported by our group and obtained in just one-third of patients with paroxysmal AF by CPVA and vagal denervation have created a perspective that with the improvement of techniques of atrial vagal denervation, AF might be cured with minimal and less extensive ablation of the atria [17]. *Ideally*, the knowledge of all the underlying mechanisms of AF would allow performing a tailored strategy for each and every patient and to choose specific tools to achieve individual endpoints, thus, preserving both the structure and function of the heart. *Realistically*, however, we believe that at present, a single standardized strategy encompassing most mechanisms including triggers, autonomic, and electrophysiologic substrates, such as CPVA (Fig. 1) with short procedure time and a high benefit/risk ratio, is the most rational approach for patients with all forms of AF, also taking into consideration that CPVA is associated with long-term morbidity and mortality benefit.

Like CPVA, other techniques now have reported excellent long-term results in restoring and maintaining sinus rhythm among patients with recurrent paroxysmal and persistent AF. Unlike CPVA, the stepwise approach recently proposed for chronic AF [18] requires very extensive lesions in both the left and right atrium to obtain the same success rates as reported by CPVA many years ago. Long-term prospective randomized studies comparing the relative impact of medical therapy and catheter ablation on "hard" outcomes of morbidity and mortality in AF are necessary to better define the patient population that may derive the greatest benefit from ablation at the lowest risk and at an acceptable cost.

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