Radiofrequency ablation for atrial fibrillation

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Complete cure of atrial fibrillation in highly symptomatic patients can now be achieved using a surgical or catheter based approach. Most electrophysiology laboratories working on catheter ablation for paroxysmal atrial fibrillation target pulmonary veins using a transseptal approach. The aim of the procedure is to achieve complete disconnection of the pulmonary veins, demonstrated by the disappearance or dissociation of their potentials. This is clearly facilitated by the use of a circular catheter dedicated to the mapping of the pulmonary vein ostia, which allows the identification of the connections from the atrium to the vein. Using this approach in targeting all four pulmonary veins, 70% of patients are cured without the need for antiarrhythmic drugs. However, some complications have been described, including tamponade, embolic events and pulmonary vein stenosis. The learning curve for this procedure is steep, but in experienced centres the safety profile is very acceptable.

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Introduction

Atrial fibrillation (AF) is the most common arrhythmia, with more than 1% of the general population affected.¹⁻³ This arrhythmia is responsible for significant costs and complications, but most importantly it may be very disabling in some patients.⁴⁻⁸ For such highly symptomatic patients, there are only two curative approaches: catheter ablation and surgery.⁹⁻⁻²⁷ For patients in whom surgery is not required for other reasons, catheter ablation offers a lower morbidity and mortality, and this procedure should therefore be considered first. In contrast, a surgical approach is preferred in those patients in whom cardiac surgery is required for another reason. The present review focuses on catheter ablation for patients with AF.

Indications

Atrial fibrillation associated with another arrhythmia

In patients in whom junctional tachycardia, atrial tachycardia, or flutter is diagnosed in association with AF, the ablation should of course target the simplest arrhythmia first. This situation is frequently observed in cases of Wolff–Parkinson–White syndrome or concealed accessory pathway, but it may also be seen with atrioventricular nodal re-entry tachycardia. The patient should be considered for AF ablation if AF persists after ablation of the other arrhythmia. Indeed, most patients with both AF and flutter will continue to have AF after flutter is ablated. After ablation of
the cavotricuspid isthmus for flutter, it is probably easier to manage patients with medical therapy and, in particular, class IC drugs.

**Paroxysmal atrial fibrillation**

Radiofrequency ablation for AF is a relatively new procedure. The procedure has been shortened and simplified, and it is becoming increasingly safe with a reasonable rate of success. However, the present approach can probably be developed further. The indications currently accepted will probably be extended in the near future. We consider for ablation those patients who have frequent episodes of fibrillation in spite of the use of two different antiarrhythmic drugs of class I or III. At least one episode of AF every 10 days is currently required, but this restriction may be relaxed in the future. However, it will probably never make sense to perform this kind of procedure in patients with infrequent episodes of AF.

It is probably preferable to offer this procedure to highly symptomatic patients. The level of complications is likely to be the same in symptomatic and asymptomatic patients, but to date there has been no demonstration of a beneficial effect of ablation on prognosis.

**Chronic atrial fibrillation**

Chronic AF is the most difficult form of arrhythmia to ablate. Currently, there is no consensus on the best approach for catheter ablation for patients with chronic AF. It will probably require the combination of long linear lesions in the left atrium as well as the ablation of all potential foci. Compared with the ablation of paroxysmal AF, the procedure is much longer and the associated risks are higher, which limits the indications. We consider only selected patients for ablation, namely those who are highly symptomatic and with poor haemodynamic tolerance and/or suspicion of tachycardiomyopathy. However, in elderly patients, His bundle ablation and pacemaker implantation is certainly easier and should probably be offered, despite the minimal risk for sudden death.

**Methods**

It is preferable to refer patients with AF to an experienced laboratory. The procedure requires the operator to be well experienced in the transeptal approach and catheter ablation in the left heart, including pulmonary veins, and the learning curve is rather steep.

It is probably safer to prepare patients with oral anticoagulation for at least 1 month before ablation. However, we have not demonstrated the superiority of this in a randomized study. In addition, transoesophageal echocardiography is systematically performed in our department to rule out the presence of a left atrial thrombus, which is found in approximately 1% of referred patients who were properly anticoagulated.

Various approaches have been described for AF ablation. In recent years the initiation of AF has been studied in more detail, demonstrating that most AF episodes are triggered by a limited number of foci located within the pulmonary veins in 80–95% of cases. In our early experience, foci were ablated by targeting the earliest activity in the vein during ectopy. However, this limited lesion of the myocardial sleeves extending into the pulmonary veins cannot prevent firing from an adjacent site. A complete disconnection of the vein has been shown to be effective at circumventing this. There is no general consensus for targeting pulmonary veins to cure patients with paroxysmal AF, but the vast majority of centres are doing so but with minor variations. The most popular approach consists of using a circular decapolar catheter to map the ostium of the veins and to guide the ablation using a conventional ablation catheter (Figs 1 and 2). The major contribution of this mapping catheter is that it allows the identification of the electrical inputs from the atria to the veins. These areas show the shortest atrial–venous potential delay in sinus rhythm or during coronary sinus pacing. Coronary sinus or left appendage pacing is very useful for differentiating between atrial and venous potentials. It also provides a very clear end-point — all venous potentials must disappear or be dissociated after the ablation. With this approach the first lesion is placed proximal to the circular catheter in front of the bipoles showing the shortest A–PVP delay. If the circular catheter activation is unchanged, then further lesions must be applied in the same area. In contrast, if the activation recorded in the vein is modified, then the bipoles showing the ‘new’ shortest A–PVP delay must be targeted, and so on until complete disconnection of the vein is achieved, as demonstrated by disappearance or dissociation of all distal PVPs. The most ‘electrophysiologically correct’ approach should consist of targeting arrhythmogenic pulmonary veins only. However, a combination of empirical evidence and a pragmatic approach suggests that systematic ablation of all four pulmonary veins should reduce the number of procedures required.
to achieve a complete cure. Again, this is acceptable only if the risk of pulmonary vein stenosis is very low, as in experienced centres.

Using this approach, 99% of the veins are successfully disconnected. The rate of recurrence of AF remains quite high, requiring more than one procedure in 40–50% of patients. However, the success rate is reasonable. Of patients undergoing ablation, 70% are cured without any treatment with antiarrhythmic drugs. With the use of a previously ineffective class IC drug, another 15% of patients are rendered free from arrhythmia.
Another approach consists of long linear lesions encircling the pulmonary vein ostia, four-by-four or two-by-two, as developed by Melo et al.\textsuperscript{17} and Sueda et al.\textsuperscript{18} This approach has been translated to catheter ablation by Kuck and coworkers\textsuperscript{19} and by Pappone et al.,\textsuperscript{20} with differences in effectiveness and complication rates. However, the most recent results reported by Pappone et al.\textsuperscript{21} are encouraging, with similar success rates both for patients with paroxysmal AF and for those with chronic AF.

What are the risks and how can they be reduced?

In addition to the risks inherent to any cardiac catheterization, there are more specific risks associated with AF ablation.

Transseptal puncture and use of long sheaths in the left atrium

The transseptal puncture is performed using dedicated transseptal sheaths. Once the puncture is made with the Brockenbrough needle, the dilator and sheaths are only pushed over the needle if there is 100% confidence that the tip of the needle is in the left atrium. In our experience, the analysis of the pressure recorded by the needle is not sufficient proof of this, and injection of contrast through the needle may increase safety by showing whether the tip of the needle is in the left atrium.

Once the long sheath is introduced into the heart, it is perfused under pressure to deliver a flow of approximately 2–4 ml/min.

Thromboembolic complications

In our series of patients, the risk for thromboembolic complications was lower than 0.5%. To reduce the risk as much as possible, the following measures are used.

Oral anticoagulation is interrupted 2 or 3 days before the ablation, which is performed in our laboratory when the INR is below 1.7. After this, a bolus of heparin 50 U/kg body weight is infused and repeated only if the procedure lasts longer than 3–4 h. After ablation, subcutaneous heparin is administered with a target of two or three times the control value for the partial prothromboplastin time.

During the procedure, radiofrequency energy is delivered using the temperature controlled mode with a target temperature of 50°C. With such a low temperature of the ablation electrode, charring or clot formation is uncommon and this probably, in part, explains the safety profile of the procedure.

Vein stenosis

In our initial experience, the use of powers ranging from 40 to 50 W was associated with pulmonary vein stenosis in 5% of cases. By decreasing the power limit to 20–30 W, the incidence of this complication has been reduced to about 1%.
Mechanical complications

Perforation may be observed during manipulation of the ablation catheter in the left atrium, particularly in the left appendage, where very thin tissue is encountered between pectinate muscle and in the roof of the left atrium where the ablation catheter is pushed after crossing the septum. The optimal use of a circular catheter also involves a learning curve. Because of the circular orientation with the proximal poles attached to the shaft of the catheter, it is safer to turn the shaft clockwise. A counter-clockwise rotation will uncoil the circular catheter, which may be unsafe. Moreover, the circular catheter should not be uncoiled in the left ventricle because it may become entrapped in the chordae of the mitral valve.

Conclusion

More than 70% of patients with paroxysmal AF may now be completely cured with transseptal catheter ablation of pulmonary veins. Despite some variation, the present approach used in most electrophysiology laboratories aims to disconnect pulmonary veins from the left atrium. At the present time, it makes sense to offer this treatment to highly symptomatic patients in whom antithrombotic treatment has failed. However, a good safety profile in experienced hands and technical improvements suggest wider indications of the procedure in the future.

References
