

Surgical Ablation of Atrial Fibrillation

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Introduction

Surgical ablation of atrial fibrillation (AF) is an effective means of eliminating AF, both with lone AF and chronic AF associated with valvular disease. The classic Maze procedure was the gold standard for eliminating AF,¹⁻³⁾ but not commonly performed because of its complexity and invasive nature. However, recent advances in the understanding of the pathogenesis of AF and development of new ablation technologies enable surgeons to perform pulmonary vein isolation, and/or create linear left atrial lesions. Recently developed surgical instrumentation enables minimum invasive AF ablation, such as epicardial AF ablation and excision of the left atrial appendage to patients with isolated AF.

In this report, we will review surgical technique and results of the Maze procedure, describe strategies for surgical ablation in patients with valvular heart disease and in those with isolated AF.

The Maze Procedure

In the Maze procedure, right and left atrial incisions and cryoablations are constructed to interrupt the multiple reentrant circuits of AF.⁴⁾ In addition, these lesions direct the sinus impulse from the sinoatrial node to the atrioventricular node along a specified route. Key components of the Maze procedure include isolation of the pulmonary veins and excision of the left atrial appendage. These features are maintained in most of the newer operations designed to ablate AF. Many centers confirmed results with restoration of sinus rhythm in 75 and 90% of patients, low risk of late stroke and very low operative morbidity and mortality.^{4,5)} Indications for the Maze procedure were

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chronic AF in patients requiring other cardiac surgical procedures and lone AF that was either highly symptomatic or associated with stroke.

Recently, there have been dramatic changes in the surgical ablation of AF. New technologies that enable rapid creation of lines of conduction block have been embraced and applied by surgeons to ablate AF in patients having concomitant cardiac surgical procedures. Modifications of these technologies enable minimally invasive epicardial surgical ablation and excision of the left atrial appendage in patients with lone AF.

New Approaches for Surgical AF Ablation: Concomitant Surgery

Two factors have been formative in the development of new surgical approaches to AF: 1) Recognition that the pulmonary veins and left atrium are critical to the initiation and maintenance of AF⁶⁾ and 2) Development of ablation technologies that use alternate energy sources to facilitate rapid and safe creation of lines of conduction block under direct vision.

Pathogenesis of AF

While the Maze procedure was designed to interrupt the multiple macro-reentrant circuits that characterize AF, new approaches are most precisely anatomically focused. There is general agreement that development of AF requires a substrate and a trigger, and that these substrates and triggers are usually located in the pulmonary veins and left atrium.⁷⁾ Haissaguerre demonstrated that paroxysmal AF originates from ectopic beats in the pulmonary veins in 94% of cases.⁷⁾ This likely relates to the anatomic transition from pulmonary vein endothelium to left atrial endothelium; at this junction, two types of tissue with different electrical properties are juxtaposed, and this may potentiate development of AF.⁸⁾ Catheter ablation of pulmonary vein foci has proven effective in ablating paroxysmal AF, and strategies that isolate all 4 pulmonary

veins have further enhanced results of catheter-based ablation.^{9,10)}

With regard to persistent and permanent AF, intraoperative left atrial mapping of patients with persistent AF demonstrated that the left atrium acted as the electrical driving chamber in most patients.¹¹⁾ In surgical patients with persistent AF and mitral valve disease, a simple left atrial procedure successfully ablated AF in 78%.¹²⁾ These data suggest that modification of the left atrial substrate, in combination with pulmonary vein isolation, is likely to be an effective strategy for elimination of persistent and permanent AF, both in patients with lone AF and chronic AF with valvular heart disease.

Results of New Surgical Ablation Procedure

New ablation tools have been developed to facilitate surgical ablation of AF. These probes and catheters rely on alternate energy sources to create long, linear lesions that block conduction. Energy sources that have been used clinically include radiofrequency, laser, ultrasound, microwave, and cryotherapy.

Thus far, the largest clinical experience is with radiofrequency energy. Radiofrequency energy uses alternating current to heat tissue. The efficacy of this modality in catheter-based arrhythmia ablation led surgeons to pursue the direct application of radiofrequency catheter systems that are available for surgical application.¹³⁾ Several different radiofrequency catheter systems are available for surgical application. These include microwave probes¹⁴⁾ and bipolar clamps.¹⁵⁾

Results of left atrial lesion sets suggest that AF is cured in 70 to 80% of patients having ablation with concomitant heart surgery.¹⁶⁾ Most treated patients have had heart disease and have received a mitral valve procedure in addition to AF ablation.¹⁷⁾ Success of AF ablation is similar regardless of whether right atrial lesions are included.¹⁸⁾ Factors that influence the procedures success include larger left atrial size, longer duration of AF, and choice of lesion set in permanent AF. After successful ablation, atrial transport function is demonstrated in 80 to 100%.^{19,20)}

After surgical ablation with alternative energy sources, perioperative AF is common, occurring in approximately 60% of patients. Although 30% of patients leave hospital in AF, many return to sinus rhythm over the ensuing 3 months. Thus, discharge in AF is not necessarily an indication of procedure failure. This high incidence of perioperative AF is greater than that observed after a clas-

sic Maze procedure, and the cause of this phenomenon is unknown.

Conclusion

If the patient has paroxysmal AF, pulmonary vein isolation alone cures AF in 80 to 90% of cases. If the patient has persistent or permanent AF and the concomitant cardiac surgical procedure is low-risk and simple, the surgeon may employ the Maze procedure or pulmonary vein isolation with left atrial lesions. In a high-risk patient or a patient requiring complex cardiac surgery, pulmonary vein isolation with left atrial connecting lesions is a reasonable approach.

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