

# Hybrid Epicardial and Endocardial Ablation of Atrial Fibrillation: Is Ablation on Two Sides of the Atrial Wall Better Than One?

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## Evolution of Surgical Ablation of Atrial Fibrillation

The success of catheter ablation of atrial fibrillation has continued to increase with the introduction of new technology, additional experience, and advances in our understanding of the targets of ablation. Nevertheless, patients with symptomatic drug refractory long-standing atrial fibrillation present a particular challenge for treatment with catheter ablation techniques. The so-called “cut-and-sew” surgical maze procedure was developed by the pioneering work of James Cox<sup>1,2</sup> to treat this patient population. This procedure was subsequently modified to reduce the complexity and time required and is embodied in the Cox-Maze-IV surgery, which is performed on cardiopulmonary bypass and uses a combination of radiofrequency ablation, cryoablation, and surgical incisions.<sup>3,4</sup>

The next step in the evolution of the procedure was the replacement of the cryoablation lesions and the surgical incisions with radiofrequency ablation alone. This step obviates the need for cardiopulmonary bypass and created an epicardial-only technique. The evolution of epicardial ablation tools created the ability to access portions of the left atrium either through mini-thoracotomies or using thoracoscopic tools. These tools were designed to address several challenges including obtaining safe access around the pulmonary veins. Currently most procedures use a bipolar clamp-like device to ablate around the antral portion of the left atrium just proximal to the pulmonary veins on each side. Completion of the box lesion requires use of an epicardial-only tool to create the roof and floor lines.<sup>5</sup>

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## Results of a Thoracoscopic Based Surgical Ablation Procedure

A number of studies have demonstrated the success of a thoracoscopically based surgical ablation procedure incorporating many of the lesions in the Cox IV maze surgical procedure.<sup>6–12</sup> There has been a convergence of approaches, with the creation of bilateral left atrial antral lesions for pulmonary vein isolation and the roof and floor lines for completion of the posterior wall box lesion. There is variability in the incorporation of the other lines, with many surgeons omitting the superior vena cava to inferior vena cava line, the line to the mitral annulus, and “trigone” line extending from the right superior pulmonary vein to the left fibrous trigone.

In addition to the variability of the procedural variables, these studies differ in terms of the patient population studied. Some of these studies have included both paroxysmal and persistent atrial fibrillation patients while others are limited to patients with persistent or long-standing persistent atrial fibrillation. Other variables include left atrial size, underlying valvular disease, and presence of left ventricular dysfunction. Thus the results of freedom from atrial fibrillation at 1 year vary with studies showing 70% to 87% success in patients with paroxysmal atrial fibrillation<sup>6–9</sup> but a lower success in patients with persistent atrial fibrillation, for example, in the range of 39% to 62% off anti-arrhythmic drugs at 6 months.<sup>8</sup>

## Rationale for a Hybrid Surgical and Catheter Ablation Approach

Particularly in patients with long-standing persistent atrial fibrillation, epicardial-only minimally invasive surgical atrial fibrillation has modest efficacy.<sup>8</sup> There are several opportunities to improve the outcomes of epicardial-only minimally invasive surgical atrial fibrillation ablation. The primary rationale for hybrid surgical and catheter ablation<sup>13–19</sup> is the assessment of gaps and the ability to ablate these gaps. A secondary goal of the catheter ablation part of the procedure is to create lesions that are surgically difficult or impossible from the epicardial surface. These include a cavotricuspid isthmus line and completion of lines to the mitral annulus. In the Cox-Maze-IV procedure cryoablation was performed at the

mitral annulus to complete the mitral annular line and endocardial radiofrequency ablation is currently used to replace these lesions.

There are biophysical reasons why the epicardial delivery of radiofrequency energy is limited in terms of energy and heat transfer. Excessive heating of the epicardial layers increases tissue impedance reducing current delivery. Thus repeat applications of energy may have diminishing returns. In addition excessive heating at the epicardial surface may occur while deeper layers of tissue are cooled by the endocardial intracavitary blood flow. Combining endocardial ablation with epicardial ablation may have advantages in creating transmural lesions, particularly in areas of increased tissue thickness or in patients with scar or extremely large atria.

### Timing of the Stages of the Hybrid Procedure

The first so-called hybrid procedures did not use catheter ablation but used electrophysiological testing to document conduction block at the time of surgical ablation.<sup>15</sup> Subsequently, hybrid procedures incorporated both an epicardial surgical ablation stage and an endocardial catheter ablation stage. Initially, catheter ablation was performed at the same sitting as the surgical thoracoscopic procedure.<sup>17,18</sup> Alternatively, however, the catheter ablation procedure may be done in a separate procedure during the same hospitalization<sup>16</sup> or several months later.<sup>19</sup> There are potential advantages of each approach. Performing the catheter ablation procedure at the same setting enables the patient to undergo a single procedure, obviating the need for a second anesthesia administration that is frequently but not always used for catheter ablation. Assessing conduction gaps during the same hospitalization may have logistical benefits since the catheter ablation is performed during the patient's recovery time and does not require a separate hospitalization. The primary benefit of performing the catheter ablation procedure 1 to 3 months after the surgical procedure is that the lesions would likely have healed and exhibit stable conduction properties, potentially being more predictive than if performed earlier.

### Results of the Hybrid Procedure

The patient population studied plays an enormous role in determining outcomes. Most studies report only 6-months or 1-year follow-up and the ideal goal of the hybrid procedure should be freedom from atrial fibrillation in 3 to 5 years. Nevertheless most of the studies to date, summarized in a well-written review paper by Gelsomino et al,<sup>13</sup> report freedom from atrial fibrillation at 6 months to be 78% to 100%. In addition, some studies report conversion to sternotomy,

tamponade, hemothorax, pneumothorax, pleural bleeding, and bleeding as complications.<sup>13</sup> In a study of only patients with long-standing persistent atrial fibrillation reported by Bulava et al, 84% of patients were free of atrial fibrillation off anti-arrhythmic drug but after 1 year there no recurrences of atrial fibrillation reported. We do not know from these studies the long-term, eg, 5 year, outcomes, particularly in patients with very large atria.

### Significance of the Hybrid Procedure

In addition to the significant success of the hybrid procedure, one of the most important advances is creation of a collaborative approach to the treatment of atrial fibrillation between cardiac surgeons and electrophysiologists. This collaboration will also permit important advances in improving the procedure, particularly in patients with very large atria (>5 cm or >6 cm dimension) or extensive scar. The vision of a combined surgical and cardiac electrophysiology program might provide an ideal venue for this approach.

### Unanswered Questions

There are numerous unanswered questions raised by the hybrid surgical-catheter ablation procedure:

***How much does each stage of the hybrid procedure add to the overall success of the procedure?***

Further clinical trials are needed to compare the outcomes of the hybrid procedure to catheter ablation alone and epicardial thoracoscopic surgery alone.

***Is one of the most important contributions of the catheter ablation stage of the hybrid procedure the feedback that is given the surgeon regarding lesion formation?*** By documenting case-by-case the completion of the posterior box lesion and other lines during the electrophysiologic study, the surgeon receives feedback that is critical to improving the results of the epicardial portion of the procedure. As a result, it is common for the surgeon to increase the number of ablation lesion applications to maximize lesion transmural.

***Which of the lesions are most important? Is a more extensive lesion set needed for long-term freedom from atrial fibrillation? What is the contribution of the endocardial lines, particularly the cavotricuspid annulus line and the mitral annular line?***

Bulava et al<sup>19</sup> found that at short-term follow-up most patients did not have complete isolation of the box lesion but most patients were free of recurrent arrhythmias. One interpretation of this observation is that complete isolation of the box lesion is not needed for a good short-term outcome. However, for long-term success will a more

complete lesion set be needed? It is possible that new reentrant wavefronts may develop over time and thus a more extensive lesion set with transmural lesions might result in the best long-term outcomes.

### Can atrial fibrillation be mapped?

The work of Narayan and Krummen<sup>20</sup> supports the concept of mapping to identify areas that can be ablated. Can mapping be combined with the hybrid approach?

### Are there ways to improve lesion transmurality?

The need for repeated applications of radiofrequency energy and the frequent absence of conduction block underscores the need for improvements in technology to make these lesions. Better tools to locate gaps are also needed.

## Conclusion

Hybrid surgical-catheter ablation of atrial fibrillation may add importantly to the treatment of patients with atrial fibrillation, particularly when it is persistent or long-standing persistent. One of the most important roles of this procedure is to create a collaborative approach between surgeons and electrophysiologists in treating atrial fibrillation, analogous to the percutaneous heart valve hybrid procedure programs. There are numerous opportunities to improve the hybrid procedure and to answer important questions regarding its long-term effectiveness, particularly in patients with dilated atria and extensive scar.

## Disclosures

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