

# Surgery for Atrial Fibrillation



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## KEYWORDS

• Cox-Maze • Atrial fibrillation • Surgical ablation • Minimally invasive

## KEY POINTS

- The Cox-Maze procedure is the current gold standard in the surgical ablation of atrial fibrillation.
- Failure to isolate the entire posterior left atrium and the pulmonary veins greatly increases atrial fibrillation recurrence.
- Advances in minimally invasive techniques and technologies have allowed for a less-invasive Cox-Maze procedure to be performed through a right mini thoracotomy.

## INTRODUCTION

Atrial fibrillation (AF) remains the most common arrhythmia, affecting more than 5 million people in the United States alone. With the aging population, the prevalence of AF has increased over the last decade and is expected to double by the year 2030.<sup>1</sup> Despite advances in treatment, AF still carries significant morbidity and mortality that stem from 2 major mechanisms: (1) asynchronous atrioventricular contractions, which result in varying degrees of hemodynamic compromise, and (2) stasis of blood in the atria that predisposes patients to clotting and subsequent thromboemboli.<sup>2</sup> The risk of stroke in patients with AF is increased by as much as 5-fold.<sup>3</sup> Most AF patients require anticoagulation, and despite the introduction of direct factor Xa inhibitors, anticoagulation predisposes to other major morbidities including gastrointestinal bleeding and hemorrhagic stroke.<sup>4</sup>

The treatment of AF represents a significant economic burden, with an estimated \$26 billion spent annually in the United States.<sup>5</sup> Antiarrhythmic medications have been the mainstay of treatment

for nearly 100 years, but their use has been limited by systemic toxicity, low efficacy, and arrhythmogenicity.<sup>6</sup> Pharmacotherapy is routinely directed at either controlling the patient's rhythm or ventricular rate. The Atrial Fibrillation Follow-up Investigation of Rhythm Management (AFFIRM) study found that management with rhythm control had no survival benefit over rate control in anticoagulated patients<sup>7</sup>; however, there was a clear survival benefit for patients that were able to achieve normal sinus rhythm.<sup>8</sup> The pharmacologic inadequacies of treating atrial fibrillation have justified a role for interventional management of atrial fibrillation.

Starting in the 1980s, several procedures were developed in an effort to treat atrial fibrillation, including left atrial isolation,<sup>9</sup> corridor operation,<sup>10</sup> and atrial transection.<sup>11</sup> However, these procedures were abandoned because of their inability to reliably prevent or cure atrial fibrillation in humans. It was not until 1987 that a team led by Dr James Cox devised the Maze procedure, now known as the Cox-Maze Procedure, which reliably and successfully treated AF.<sup>11</sup> This review discusses the indications for surgical ablation of AF

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and the technique and results of the Cox-Maze IV (CMIV) procedure.

## INDICATIONS FOR SURGICAL ABLATION OF ATRIAL FIBRILLATION

In 2007, a task force that included the Society of Thoracic Surgeons, American College of Cardiology, Heart Rhythm Society, European Heart Rhythm Association, and European Cardiac Arrhythmia Society was established to create a consensus statement on AF surgical and catheter-based treatment.<sup>12</sup> Over the last several years, a large volume of literature has evaluated the efficacy and safety of not only catheter-based ablation but also surgical ablation. Also, the advent of ablation technology has allowed for greater flexibility of the surgical approach and has expanded the indications, particularly for concomitant AF procedures, in patients undergoing other cardiac surgery.

The task force reconvened in 2012 and released the consensus indications for surgical ablation divided into 2 separate categories: those patients undergoing concomitant cardiac surgery and those having stand-alone surgical treatment of their AF.<sup>13</sup> For those undergoing other cardiac surgical procedures, all patients with symptomatic atrial fibrillation should be considered for surgical ablation, regardless of whether antiarrhythmic medications have been started. Ablation should also be considered in selected asymptomatic patients in whom adding an ablation procedure would not add to operative morbidity or mortality. However, stand-alone surgical ablation is generally indicated in patients with symptomatic AF who do not respond to medical therapy and have had one or more failed catheter ablations or prefer surgical therapy.<sup>13</sup>

## SURGICAL TECHNIQUE: COX-MAZE IV PROCEDURE

### Preoperative Planning

To simplify the CMIII, our group at Washington University replaced most of the cut-and-sew lesions that comprised the CMIII with a combination of bipolar radiofrequency ablation and cryoablation and have termed the revision the *CMIV*. All patients receive a transthoracic echocardiogram to determine left atrial (LA) LA size and the presence of valvular disease. LA size in particular is important because LA diameter is a strong predictor of procedural success, with a diameter of  $\geq 8$  cm associated with a failure rate of greater than 50%.<sup>14</sup> Although transthoracic echocardiogram also can be used to evaluate for the presence of LA clot, this finding needs to be confirmed intraoperatively with

transesophageal echocardiography. In patients do not respond to catheter ablation, a contrast chest computed tomography scan is obtained to evaluate the pulmonary veins.

This procedure can be performed through either a sternotomy or a less-invasive right mini thoracotomy (RMT). Our group prefers an RMT approach in the absence of contraindications, which include previous right thoracotomy, severe atherosclerotic disease of the aorta, iliac or femoral vessels, and severely decreased left ventricular ejection fraction ( $\leq 20\%$ ). All patients scheduled to have an RMT receive a computed tomography angiogram of the thoracic and abdominal aorta as well as the femoral arteries if they are older than 40 years, have risk factors for the development of peripheral vascular disease, or have demonstrate evidence of peripheral vascular disease on physical examination. An RMT approach can be used in patients receiving a concomitant mitral or tricuspid valve procedure. Other concomitant procedures, such as aortic valve replacement, are performed through a sternotomy approach.

### Positioning

Positioning is dependent on the approach being used. In a sternotomy approach, patients are placed supine with both arms tucked. In an RMT procedure, the patient is intubated using a bronchial blocker placed in the right main stem bronchus allowing for right lung deflation. The patient is then placed supine with the hips flat but the right chest elevated  $30^\circ$  to  $45^\circ$ . The right arm is placed over the head in anatomic position with the aid of an arm board, and the left arm is tucked. Both groins are prepped with antiseptic solution in the RMT approach in preparation for femoral cannulation (**Fig. 1**).

### Operative Technique

There are several important differences between the sternotomy and RMT approaches. An outline of each approach and its lesions sets are listed below followed by a description of the key operative steps. Each RF ablation line is created by performing 2 to 3 firings of the bipolar RF clamp. This is done to assure a transmural lesion.<sup>15</sup>

#### **Sternotomy approach**

- Median sternotomy, central cannulation of superior vena cava (SVC), inferior vena cava (IVC), and aorta and initiation of cardiopulmonary bypass (CPB)
- Right and left pulmonary vein isolation (PVI)
- Right atrial (RA) lesion set (**Figs. 2A and 3**)

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