Interim Results of the 5-Box Thoracoscopic Maze Procedure

John H. Sirak, MD, and David Schwartzman, MD

Division of Cardiac Surgery, Ohio State University, Columbus, Ohio; University of Pittsburgh Heart and Vascular Institute, Pittsburgh, Pennsylvania

Background. **In accordance with the Cox-Maze paradigm, successful treatment of atrial fibrillation (AF) requires (1) complete posterior left atrial isolation, (2) elimination of corridors for perimitral reentry, (3) elimination of cardiac venous (superior vena cava and coronary sinus) arrhythmogenic foci, (4) complete autonomic denervation, and (5) occlusion or removal of the left atrial appendage. Using a totally thoracoscopic approach, isolation of all left atrial arrhythmogenic substrate is achieved through the creation of 5 discrete but contiguous compartments, thereby enabling unambiguous verification with bidirectional block. Since no previous closed-chest procedure incorporates all these end points, an update on patient outcomes is reported.**

Methods. **One hundred seventy-nine consecutive patients with antiarrhythmic drug–resistant AF (3 paroxysmal, 5 persistent, 171 longstanding persistent cases), known preoperatively for 5.7 (range 0.5 to 25) years, underwent the 5-box thoracoscopic Maze procedure. Only 1 patient suffered a serious procedural complication (sternotomy for pulmonary artery injury). Postoperative rhythm surveillance consisted of 1 week of continuous ambulatory monitoring at 3, 6, 13, and 24 months. Failure was defined as any tachyarrhythmia exceeding 30 seconds beyond the 3-month anniversary.**

Results. **Freedom from AF was observed in 137 of 142 patients at 3 months, 115 of 119 patients at 6 months, 75 of 78 patients at 13 months, and 24 of 25 patients at 24 months. Two patients remain in sinus rhythm on low-dose antiarrhythmia therapy. Warfarin is discontinued only after the first monitoring session confirms rhythm stability.**

Conclusions. **Replication of the left atrial Cox-Maze lesion set through a totally thoracoscopic approach isolates virtually all arrhythmogenic substrate. Meticulous verification of compartment integrity allows for outcomes equivalent to the Cox-Maze benchmark.**

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Current understanding of the mechanism of atrial fibrillation (AF) focuses on 4 mechanisms. First, the endothelial transition zone at the junction of the pulmonary veins with the left atrium has been demonstrated by Haissaguerre and colleagues [1] to contain a high frequency of ectopic triggers capable of initiating AF. Second, heightened sympathetic and parasympathetic inflow mediated by epicardial autonomics elicit AF by increased ectopy in the pulmonary veins and by a shortened refractory period in the atrial myocardium [2]. Third, structural heterogeneity of the left atrium promotes anisotropic conduction, forming focal triggers that serve as reentrant rotors capable of sustaining fibrillatory conduction [3]. Finally, the persistence of AF over time produces ion channel remodeling, thereby increasing automaticity and the tendency for AF to become permanent [4].

In accordance with the Cox-Maze paradigm, successful treatment of AF requires (1) complete posterior left atrial isolation, (2) elimination of corridors for perimitral macro-reentry, (3) elimination of cardiac venous (pulmonary vein, superior vena cava, and coronary sinus) arrhythmogenic foci, (4) complete autonomic denervation, and (5) occlusion or removal of the left atrial appendage. Using a totally thoracoscopic approach, isolation of all left atrial arrhythmogenic substrate is achieved through the creation of 5 discrete but contiguous compartments, thereby enabling unambiguous verification with bidirectional block [5]. Since no previous closed-chest procedure incorporates all these end points, an update on patient outcomes is reported.

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Address correspondence to Dr Sirak, 410 W 10th Ave, Doan N-820, Columbus, OH 43210; e-mail: johnsirak@gmail.com.

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Patients and Methods

Patient Selection

This retrospective analysis was completed in accordance with institutional review board guidelines. Over a 36-month period, a total of 229 patients underwent the 5-box thoracoscopic Maze procedure. Two hundred twenty of these patients had longstanding persistent AF, 6 had persistent AF, and 3 had paroxysmal AF. Inclusion criteria consisted of medical refractoriness, with or without AF-associated symptoms. Sixty-seven patients had previously undergone at least 1 percutaneous left atrial ablation. Exclusion criteria consisted only of a history of a previous thoracic operation or of severe emphysema associated with prohibitive pulmonary function test results, typically consisting of a 1-second forced expiratory volume less than 1 L. Routine preoperative testing consisted of a 12-lead electrocardiogram, a chest roentgenogram, a transthoracic echocardiogram, and a nuclear myocardial stress evaluation.

Operative Technique and Electrophysiologic Verification

The patient is positioned supine with a large padded roll between the spine and the left scapula. The arms are tucked. Right-sided access consists of an initial port in the fifth interspace at the anterior axillary line. The thoracoscope is then used to place additional ports in the sagittal plane of the transverse sinus and 1 interspace cephalad, as well as directly over the aortic root just lateral to the internal mammary bundle. The pericardium is divided 2 cm anterior to the right phrenic nerve. The pericardiotomy extends caudally to the diaphragm, with clear visualization of the oblique sinus and the inferior vena cava. The pericardiotomy is continued cephalad up to the reflection and onto the superior vena cava and then medially to the aorta. An additional window of pericardium is resected anteriorly over the aortic root. Retraction sutures are placed (Endo Stitch AutoSuture, Covidien, Mansfield, MA) on the posterior leaf of the pericardium at the levels of the transverse and oblique sinuses.

The superior vena cava is mobilized up to the azygous vein and is encircled with a flexible catheter for retraction anteriorly. A preliminary dissection of the areolar fat between the right pulmonary artery and the dome of the left atrium is performed (Fig 1). The oblique sinus is skeletonized completely.

The right pulmonary veins are encircled using the Lumitip (Atricure, Inc, Cincinnati, Ohio) dissector. Baseline pacing and conduction studies are performed on each pulmonary vein and on the confluence. High frequency of the epicardial autonomics according to the manner of Mehall and associates [6] with each site stimulated at 1000 Hz, with a doubling of the R-R interval qualifying as a positive response. The positive sites are noted for repeated testing subsequent to the pulmonary vein isolation.

Isolation of the pulmonary veins is performed with a dry bipolar radiofrequency clamp (Atricure Inc). Inclusion of the autonomic-bearing interatrial groove tissue into the clamp is facilitated with use of an endoscopic Kittner dissector. Bidirectional block of both pacing and sensing across the ablation line is confirmed separately for each pulmonary vein and at the confluence. Exit block is confirmed throughout this procedure at an amplitude of 15 mA. The interatrial groove and oblique sinus are ablated extensively (Atricure multifunctional linear pen [MLP], Atricure Inc) to extinguish all local autonomic ganglia, which is subsequently confirmed with repeated high-frequency stimulation. The distal coronary sinus is ablated under direct visualization.

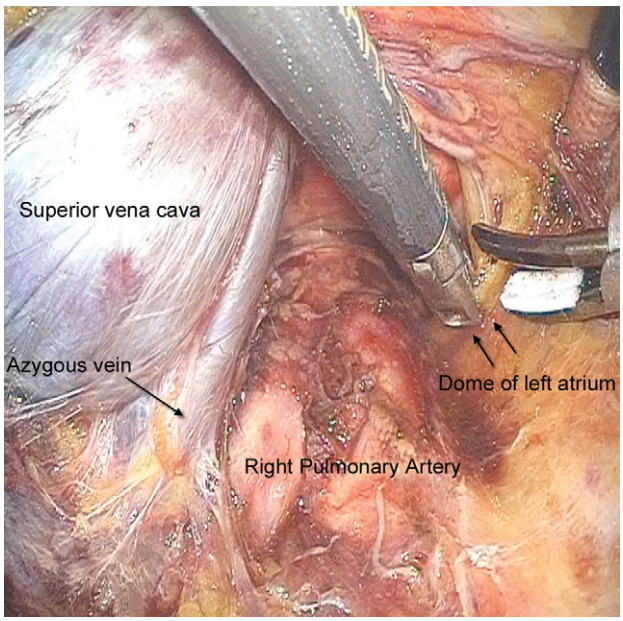

Fig 1. Initial dissection of transverse sinus. Mobilized superior vena cava is retracted anteriorly, and areolar fat between right pulmonary artery and dome of left atrium is divided.

The dissection of the transverse sinus is completed. The defect in the areolar tissue between the right pulmonary artery and left atrium created by the Lumitip dissector allows visualization of the posterior pericardium, thus establishing a clear plane of dissection across the entire transverse sinus.

The dissection of the transverse sinus is carried across the ligament of Marshall onto the pericardial reflection of the left superior pulmonary vein. Additional areolar fat overlying the dome of the left atrium is removed (Fig 2).

Under transesophageal echocardiographic guidance, the anterior trigone of the mitral annulus is localized at the left noncoronary commissure of the aortic root, as confirmed by gentle balloting of the area with the MLP device inserted through the port over the aortic root (Fig 3).

With the thoracoscope placed in the upper port, a line of multiply redundant overlapping ablations is created extending from the left noncoronary root posteriorly, traversing the base of the left atrial appendage, and onto the left superior pulmonary vein (Fig 4). It must be