Operative Techniques in Thoracic and Cardiovascular Surgery

Minimally Invasive Bi-Atrial CryoMaze Operation for Atrial Fibrillation

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The Cox maze III operation (CMIII) pioneered by Dr. Cox remains the gold standard for treatment of atrial fibrillation (AF); however, it has yet to gain widespread application due to its perceived invasiveness and complexity. The "holy grail" for AF therapy is a safe, minimally invasive procedure that can provide the same freedom from AF as the CMIII operation, which has achieved >96% freedom from AF at >5 years mean follow-up.[1]

Patients prefer a sternotomy-sparing approach, which offers cosmetic advantages and may allow for earlier recovery of normal function. However, these objectives should not affect the primary objective of eliminating AF and minimizing the risk of late thromboembolism. With the introduction of catheter-based unipolar radiofrequency ablation (RFA), interventional treatment of AF has become increasingly popular.[2] However, catheter-based techniques are often laborious and time-consuming and most results have been disappointing. Unipolar RFA has been found to be a potentially dangerous energy source whether used percutaneously or surgically, with development of fatal left atrial to esophageal fistulas in both instances.[3] In addition, catheter-based RFA cannot create a complete left atrial lesion set. To offer patients >90% freedom from AF and cerebral thromboembolism, pulmonary vein isolation alone is likely to be inadequate. Despite the work of Haissaguerre and coworkers,[4] the experience from the Cleveland Clinic has demonstrated that the lesion from the pulmonary veins to the mitral valve annulus is very important and reduced their rates of recurrent AF from ~40% to ~20% at 1 year.[5] This may explain why most reports of long-term follow-up after percutaneous AF ablation show only 70% to 80% freedom from AF. In addition, and perhaps more importantly, the left atrial appendage (LAA) is left open when using a percutaneous approach, thereby leaving patients with the potential for thromboembolism, as ~90% of left atrial thrombus is felt to originate from the LAA.[6] At this moment, percutaneous treatment of AF remains an imperfect means of managing patients with AF.

With the introduction of multiple new energy sources intended to simulate "cut and sew" lesions, there is renewed interest in surgical AF ablation. Apart from cryothermy, all of the new energy sources currently in use for AF ablation (unipolar or bipolar RFA, microwave, high-frequency ultrasound, and laser) are limited by their potential to damage adjacent structures, such as the atrial endothelium, esophagus, coronary arteries, or valvular tissues. Cryothermy has always been an important part of the CMIII operation[7] and is the only energy source currently available that can safely re-create all of the lesions of the CMIII operation, including the lesions down to the mitral and tricuspid annuli.

Traditional cryothermy was delivered by a liquid nitrogen-cooled probe (Frigitronics; CooperSurgical Inc, Trumbull, CT), which achieved temperatures of approximately −60°C, with probes that were not very flexible. Current cryothermy technology uses argon gas as the refrigerant (CryoMaze Probe; ATS Medical, Plymouth, MN)[8] and provides faster cryothermy to the tissues, with temperatures as low as −160°C, delivered by a flexible, linear probe. Studies of animal tissues have demonstrated effective transmural lesion creation after application of the Cryocath probe to cardiac tissues of up to 4 mm thickness for 60 seconds (Surgifrost Chronic Dosing Study, communication from Cryocath). In addition, cryothermy has an excellent safety profile, causing less endothelial damage than unipolar RFA (noted by an absence of char formation), with no reports of esophageal injury or left atrial fistula formation. Finally, the CryoMaze probe is well suited to a minimally invasive or robotic approach because it is a flexible, linear device with a 4-mm diameter, available in lengths of 6 to 10 cm.

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We believe that the other critical factor affecting long-term freedom from AF after surgical ablation is the lesion set. Although there is a large interest in minimally invasive techniques that apply energy epicardially, these approaches suffer from an inability to reliably create the lesion from the pulmonary vein orifices to the mitral valve annulus—a lesion that is important for prevention of left atrial flutter and recurrent AF postoperatively, as noted by the Cleveland Clinic experience.[5] This is the reason our technique involves cardiopulmonary bypass, cardiac arrest, and endocardial lesions.

Contraindications to a minimally invasive approach include previous right lung surgery or dense adhesions, forced expiratory volume <1 L, or significant peripheral vascular disease. If a patient requires concomitant coronary artery bypass or aortic valve surgery, the CryoMaze operation can still be performed through a sternotomy incision.

We present our technique of the minimally invasive CryoMaze, along with early results in a small group of patients with isolated AF.