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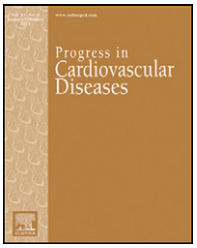

Hybrid Treatment of Atrial Fibrillation

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ABSTRACT

Endocardial catheter ablation (CA) and surgical Maze-like procedures have become mainstays of interventional treatment for atrial fibrillation (AF). However, CA has limited efficacy particularly in patients with persistent AF who have a high risk of recurrent AF. Epicardial CA in conjunction with endocardial CA, a hybrid CA, offers the potential advantage for robust lesion formation, left atrial debulking, and mapping and CA of residual arrhythmia circuits. Hybrid CA procedures may improve the success rate of an ablation procedure for AF, particularly in those with persistent or long-standing persistent AF and those with significant structural heart disease. However, the ideal patient populations who may benefit from hybrid AF ablation and the ideal tools and techniques for hybrid AF ablation have yet to be determined. In this review, we discuss the hybrid CA procedure including motivation for and methods of hybrid CA, available tools, and reported efficacy of the procedure.

Catheter ablation (CA) of atrial fibrillation (AF) is limited by an unacceptable recurrence rate.[1] Multiple factors likely contribute to AF recurrence after CA including: progression of the underlying disease processes, inadequate ablation of important targets for therapy, and reversibly injured sites of ablation.

Approaches to the interventional management of AF emerged from two distinct schools of thought over the last four decades. Surgical approaches to the management of AF in patients undergoing concomitant cardiac surgery or as a standalone procedure drew from the belief that AF could be managed through atrial debulking and modification of the underlying substrate to minimize the chances of sustained atrial reentry circuits.[2] However, open surgical standalone procedures for AF management, although quite effective, were not broadly adopted due to their associated morbidity.

Initial approaches with endocardial CA of AF drew from the belief that AF could be managed by the elimination of triggers located in the pulmonary veins by focal and segmental ablation.[3] Subsequent studies extended the CA target to antral pulmonary vein isolation with the putative additional targets of ganglionated plexi modification and treatment of substrate in the antral left atrial (LA) tissue.[4] However, endocardial CA has been limited by inadequacy of lesion creation and the inability to feasibly target broad swaths of atrial tissue for ablation.[5]

Hybrid ablation for AF can be viewed as a convergence of these two schools of thought in the pathophysiologic understanding and interventional management of AF.

Minimally invasive epicardial surgical ablation allows for atrial debulking with long-standing, robust lesion formation through direct epicardial contact with large linear ablation catheters. However, minimally invasive epicardial CA procedures are limited in the locations for ablation due to pericardial reflections. In addition, there are limitations in the ability to

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Abbreviations and Acronyms

AADT = anti-arrhythmia drug therapy

AF = atrial fibrillation

CA = catheter ablation

LA = left atrial or atrium

LAA = left atrial appendage

NSR = normal sinus rhythm

PV = pulmonary vein

PVI = pulmonary vein isolation

RF = radiofrequency

perform detailed mapping during ablation. In the hybrid epicardial–endocardial ablation procedure, the epicardial portion of the procedure is followed by endocardial ablation where detailed mapping of lesion efficacy and residual atrial tachycardia can be performed, and ablation of areas inaccessible from the epicardial surface can be performed.

Surgical treatment of AF

Surgical treatment of AF was developed with the notion that debulking of atrial tissue by creating scars can result in the creation of smaller isolated segments of atrium preventing reentry circuits required to sustain AF. Described in 1985, the first of these techniques, the "Corridor" procedure, isolated the sinus node along with a small corridor of atrium from the rest of the atrium giving the patient normal sinus rhythm (NSR), while the rest of the atrium was still fibrillating.[6] Subsequently, James Cox developed the Maze procedure in the 1980s, surgically dividing the atrium into even smaller segments.[2] Isolated segments included the pulmonary veins (PVs) and the posterior wall of the LA. Modifications of the Maze procedure lead to the Cox-Maze III procedure[7] (Fig 1) becoming the gold standard procedure for surgical management of AF.[8]

Damiano et al replaced surgical cut-and-sew lesions with new ablation technologies including radiofrequency, cryothermy, or microwave energy ablation resulting in the so-called Cox-Maze IV.[9] Khargi et al[10] demonstrated that the efficacy of alternative energy sources was comparable to a cut-and-sew technique. Although cardiopulmonary bypass is still required with alternative sources to improve efficacy of lesions, cross clamp times are much less compared to cut-and-sew techniques.

Similar epicardial ablation techniques have been used for the treatment of AF patients undergoing concomitant heart surgery. Although concomitant Maze surgery has been demonstrated to significantly improve AF free survival in these patients, only 62% of patients undergoing mitral valve surgery currently undergo concomitant Maze procedure.[11] In a meta-analysis of 9 randomized controlled trials,[12] among 472 patients, surgical maze increased the odds of freedom from AF at 12 months after cardiac surgery over 5-fold. There was no corresponding increase in hospital stay, peri-operative complications, or mortality.

Thoracoscopic or mini-thoracotomy approaches have been developed to perform epicardial off-pump PV isolation (PVI). Initial results with bilateral video-assisted thoracoscopic epicardial PVI using a bipolar non-irrigated radiofrequency (RF) clamp (Synergy RF, Atricure, Inc, Cincinnati, OH) were promising with 91% free of AF at follow-up.[13] However, the majority of patients in these studies had paroxysmal AF. Because endocardial CA is highly effective for paroxysmal AF and is much less invasive, the more invasive standalone epicardial ablation has not gained acceptance for paroxysmal AF.

The addition of linear lesions to epicardial PVI may be beneficial for the treatment of persistent AF. Edgerton et al developed and evaluated beating heart approaches to achieve a close approximation of the Cox-Maze lesion sets, known as the "Dallas" lesion set using a bipolar RF clamp and linear ablation catheter (Atricure, Inc).[14] The lesion sets included pulmonary vein isolation using the bipolar RF clamp, ganglionated plexi ablation, a LAl roof line, a line between the roof and the left fibrous trigone (anterior trigone line), and a line to the base of the resected LA appendage (LAA; Fig 2). Conduction block across the roof and anterior trigone lines were verified by pacing techniques. This lesion set in persistent AF patients led to freedom from AF on 6 months follow-up of 58% and 80% off and on antiarrhythmic drug therapy (AADT) respectively as documented by long-term (14–21 day) event monitor.

Larger studies have evaluated standalone epicardial minimally invasive techniques for persistent AF. Weimar et al evaluated "Dallas" epicardial lesion sets in 89 patients (35% paroxysmal AF) and demonstrated freedom from AF and AADT of 90%, 82% and 71% at 6, 12 and 24 months, respectively.[15] Nasso et al[16] evaluated another minimally invasive epicardial ablation procedure with a unipolar RF ablation catheter (Cobra, Atricure, Inc) looped around the PVs by way of transverse and oblique pericardial sinuses assisted by a magnetically tipped introducer. Although the majority (96%) of the patients had paroxysmal AF, freedom from AF at a mean follow up of 17 months was seen in 89% of the patients. A comparative study of catheter ablation against standalone minimally invasive surgical AF ablation ("Dallas"

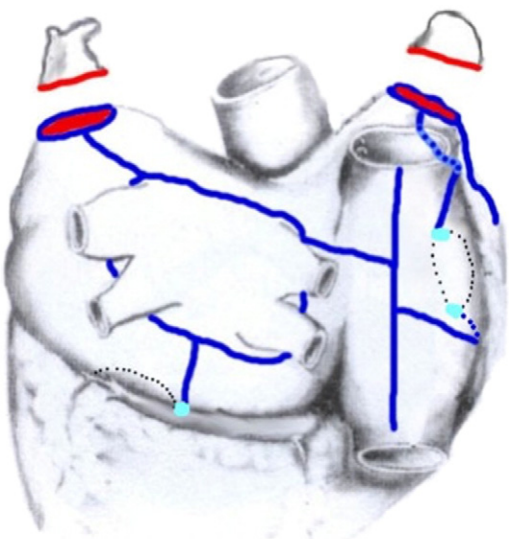

Fig 1 – The typical lesion set of the Cox-Maze III standalone surgical procedure.