MINIMALLY INVASIVE ATRIAL FIBRILLATION SURGERY: HYBRID APPROACH

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Abstract

Atrial fibrillation is a challenging pathologic process. There continues to be a great need for the development of a reproducible, durable cure when medical management has failed. An effective, minimally invasive, sternal-sparing intervention without the need for cardiopulmonary bypass is a promising treatment approach. In this article, we describe a hybrid technique being refined at our center that combines a thoracoscopic epicardial surgical approach with an endocardial catheter-based procedure. We also discuss our results and review the literature describing this unique treatment approach.

Introduction

Atrial fibrillation (AF) continues to be a common and challenging disease process and is increasing in both incidence and prevalence.[1] Typically, AF causes symptoms of fatigue, palpitations, and shortness of breath. Moreover, individuals with atrial fibrillation can have annual stroke rates ranging from 2% to 10%.[1,2]

The initial Cox-maze cut-and-sew procedure was first developed nearly 3 decades ago and at the time was the only available option for patients with atrial fibrillation refractory to medical management.[3] Although reports demonstrated efficacy, this procedure was not broadly adopted due to its invasive nature and surgical complexity.[4] Since its development, there have been numerous iterations of the original approach, and novel energy sources have permitted innovative minimally invasive options.[5] Success with a stand-alone, video-assisted thoracoscopic surgical approach was first demonstrated in 2005,[6] however, this approach did not treat some lesions that had been defined in the Cox-maze procedure. More recently, data have emerged in support of a combined hybrid solution that uses a minimally invasive thoracoscopic epicardial ablation followed by a staged catheter-based endocardial ablation.

Consistent among each technique is the adherence to the principle of arrhythmogenic foci isolation. On the epicardial surface, this requires lesions encircling the pulmonary veins; however, additional epi- and endocardial left and right atrial lesions should be completed. A hybrid intervention using both surgical and catheter-based techniques allows for completion and testing of these conduction-blocking lesions.

Indications and Patient Selection

Hybrid thoracoscopic atrial fibrillation ablation is generally reserved for patients with (1) paroxysmal AF with prior failed catheter ablation that is refractory to medical management, or (2) symptomatic patients with persistent or longstanding persistent AF. However, consensus recommendations for hybrid approaches do not exist in the 2014 ACC/AHA/HRS guidelines for the management of patients with atrial fibrillation. The committee did put forth a Class IIB recommendation for surgical ablation in standalone AF.[7]

Relative contraindications to this approach include patients who are unlikely to derive a benefit from the procedure, including those with a severely reduced ejection fraction (< 25%), left atrial diameter greater than 6.5 cm, AF duration greater than 10 years, or prior thoracic surgery. Absolute contraindications include significant structural/valvular heart disease, left atrial thrombus, or prior cardiac surgery.

Our Technique

Patient Positioning and Preparation

Large-bore intravenous access and arterial pressure monitoring are obtained prior to induction of anesthesia. The patient is intubated with a double-lumen tube. A pulmonary arterial catheter is not used as it would restrict superior vena cava encircling lesions. Intraoperative transesophageal echocardiography (TEE) is used to confirm the absence of left atrial appendage thrombus and structural cardiac pathology. The patient is placed in the supine position with tucked arms, and two inflatable positioning devices (such as intravenous pressure bags) are placed under each scapula to allow for selective elevation of the left and right sides. The chest is prepped widely to allow access to both thoracic cavities, the sternum, and the groin. We find the use of sterile defibrillator pads helpful for maintaining sterility. Femoral arterial and venous access is obtained in case rapid initiation of cardiopulmonary bypass is required.

Bilateral Thoracoscopic Epicardial Ablation

The right-sided video-assisted thoracoscopic (VATS) component begins with placement of a 12-mm trocar in the third or fourth intercostal space in the anterior axillary line under single lung ventilation. Insufflation of the chest is commenced to a target pressure of 8 mm Hg, which aids significantly in exposure. The main working 12-mm port is placed in the fifth or sixth intercostal space above the top of the xiphoid in the midclavicular line. Finally, a 5-mm trocar is placed in the second or third interspace in the midclavicular line. Once access to the chest is established, the pericardium is opened 2 cm anterior to the phrenic nerve using a LigaSure™ device (Medtronic, Inc., Dublin, Ireland). The pericardial incision is extended superiorly to the pericardial reflection onto the superior vena cava and inferiorly to the oblique sinus. The inferior edge of pericardium is then retracted with pericardial stay sutures through separate stab incisions in the lateral chest wall. Blunt dissection of the transverse and oblique sinuses are completed to visualize the right pulmonary veins and dome of the left atrium.

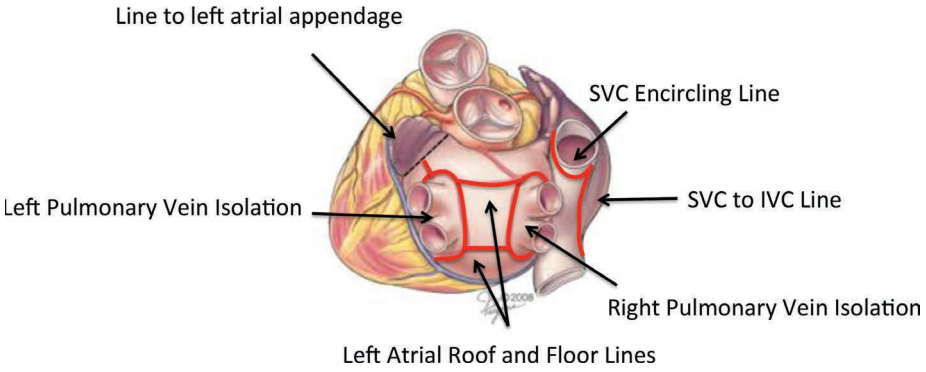

Figure 1. Posterior view of epicardial ablation lines.

A Lumitip Dissector (AtriCure, Inc., West Chester Township, OH) is inserted posterior to the pulmonary veins in an inferior-to-superior fashion until the tip of the instrument is superior to the left atrium. A vessel loop is passed around the pulmonary veins to maintain control once the dissector is removed. The Synergy clamp (AtriCure) is then gently closed around the left atrium, targeting a medial position far from the ostia of the pulmonary veins. Approximately five successive ablative scars are created using radiofrequency energy. The clamp is then removed and lesions are tested using the AtriCure Isolator® multifunctional pen to ensure full bidirectional block. Ganglionic plexi are tested in this region. Those that are active and induce a bradycardic response are ablated and retested to ensure ablation. Lesions across the dome and floor of the left atrium are then initiated using a Coolrail linear ablation pen (AtriCure) beginning at the right superior and inferior pulmonary veins and later completed via the left video-assisted thoracoscopic surgery (VATS) approach. The Isolator pen is used to create a line from the superior vena cava to the inferior vena cava. Then, an encircling lesion on the superior vena cava is created, taking care to ensure that the lesion is well above the sinoatrial node. Two 5-mm clips are placed at the junction of the transverse left atrial lines and the pulmonary vein isolation line to facilitate fluoroscopic visualization during the subsequent catheter ablation. Finally, the pericardium is closed with a single interrupted 0-braided suture, and a 24F drain is placed in the right hemithorax.

The left-sided VATS component begins with three port access sites similarly located to those on the right side but adjusted posteriorly to account for the apex of the left ventricle. The LigaSure device is used to incise the pericardium posterior to the phrenic nerve, and the Ligament of Marshall is divided. Dissection and ablation of the left pulmonary veins is completed in a similar fashion to the right side. Bidirectional block is again confirmed. Active ganglionated plexi are similarly tested and, if active, ablated with confirmation. The atrial roof and floor lesions are completed using the Coolrail ablation device by extension to the left pulmonary vein isolation line. The block in the posterior wall of the left atrium is tested with the Isolator pen. Additionally, a lesion from the left pulmonary vein isolation line to the tip of the left atrial appendage (LAA) is created with the Isolator pen. The base of the LAA is measured with the AtriClip sizing tool, and an appropriately sized AtriClip is selected. The appendage is gently positioned between the arms of the clip. Transesophageal echocardiography is used to confirm complete exclusion of the LAA prior to final closure of device. Finally, 5-mm clips are placed at the junction of the pulmonary vein isolation line and the roof and floor of the atrium for fluoroscopic orientation, and a 24F drain is placed in the left hemithorax.

Catheter-Based Component

The catheter-based component is typically performed under conscious sedation either a few days or weeks post-surgery. Surgical ablation lines are confirmed and the remaining lesions are completed. The superior vena cava line is first confirmed to ensure complete bidirectional block. Subsequently, a cavotricuspid lesion is created and bidirectional block confirmed. Next, a coronary sinus ablation is completed using intracardiac echocardiography to ensure extension to the left atrial side. These three initial steps are completed on all patients. Following this initial sequence, isoproterenol is infused to induce further atrial arrhythmia. If atrial fibrillation or flutter is successfully induced, a transseptal puncture is made (following heparin infusion to a goal activated clotting time of 350 s), and the induced flutters are mapped and ablated. Pulmonary vein isolation and left atrial roof line block is tested. Isoproterenol infusion is then repeated to ensure no remaining flutter is present. If atrial fibrillation was initially induced, pulmonary vein isolation lines are tested followed by completion of a mitral isthmus line and complex fractionated atrial electrogram. If isoproterenol initially failed to induce atrial flutter or fibrillation, a transseptal puncture is not created and the procedure is completed following the initial three-stage sequence.

Patients are maintained on anticoagulation and antiarrhythmic medication for 3 months. Following this blanking period, patients are gradually weaned depending on the results of a 7-day Holter monitor evaluation.

Our Results

In one of the early studies on the hybrid approach, we reported our initial results of 15 patients.[8] This cohort was matched, in a 2:1 fashion, with 30 patients who underwent sequential catheter ablations. Patient data and outcomes are listed in Table 1. Following VATS ablation, all 15 patients were in sinus rhythm (three required perioperative cardioversion) prior

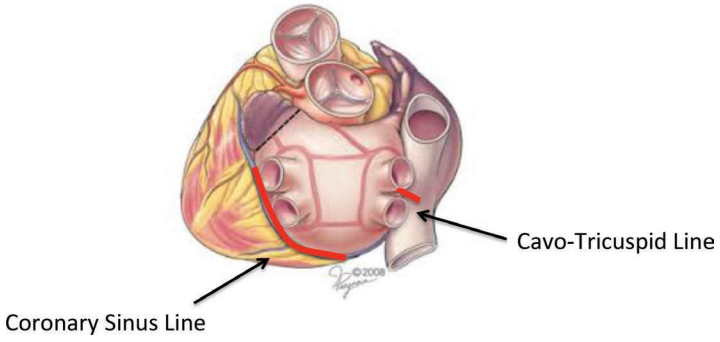

Figure 2. Posterior view of endocardial ablation lesions.

Variable	Hybrid (n = 15)	Catheter – alone (n = 30)	*P* Value
Patient (age)	59.5 ± 2.4	59.2 ± 1.5	0.9
Gender (female)	7 (46.7%)	11 (36.7%)	0.54
Hypertension	7 (46.7%)	20 (66.7%)	0.22
Diabetes mellitus	3 (20.0%)	4 (13.3%)	0.67
Atrial fibrillation type			
Persistent	9 (60%)	24 (80%)	
Long-standing persistent	6 (40%)	6 (20%)	
Total number of ablations	1.7 ± 0.2	1.2 ± 0.1	0.01
Outcome			
Stroke	0 (0.0%)	0 (0.0%)	—
Tamponade	0 (0.0%)	1 (3.3%)	> 0.99
Hematoma	0 (0.0%)	2 (6.7%)	0.55
Freedom from atrial arrhythmia			
Off antiarrhythmic drugs	13 (86.7%)	16 (53.3%)	0.04
On antiarrhythmic drugs	14 (93.3%)	17 (56.7%)	0.01

Table 1. Selected baseline characteristics and outcomes for hybrid procedure versus catheter-alone procedures.

to catheter ablation, which was performed at a mean interval of 4.3 ± 1.3 days. Seven patients required ablation of additional inducible lesions at the time of the catheter-based procedure. At a mean follow-up of 20.7 ± 4.5 months, freedom from atrial arrhythmias (off of antiarrhythmic drugs) was 86.7% in the hybrid group vs 53.3% in the repeat catheter groups ($P = 0.04$). There were no major complications, conversion to sternotomy, or conversion to thoracotomy in the hybrid group, but one patient in the sequential catheter group required pericardiocentesis for cardiac tamponade.

Discussion

The initial data on a hybrid minimally invasive surgical/catheter-based approach for standalone AF have been promising. However, our understanding of the efficacy of this treatment paradigm is hindered due to the great variability that exists between centers with respect to patient inclusion, timing of stages, lesions performed, and post-procedural protocol and follow-up. Our initial series only included patients with persistent AF or long-standing persistent AF (LSPAF) who had previously failed both a catheter ablation and at least one antiarrhythmic drug.[8] This is in contrast to many other studies that included a significant proportion of individuals with paroxysmal AF (PAF).[9-13] A study of a staged hybrid procedure by Bisleri et al. included 45 patients, all of whom had LSPAF with a mean duration of 83.8 ± 69.1 months.[14] At a mean follow-up of 28.4 ± 1.7 months, 88.9% of patients were free from AF, which was evaluated via an implantable loop recorder. Our results are consistent with a number of more recent studies that demonstrated greater than 85% freedom from AF while off antiarrhythmic drug therapy at 1 year.[9-11] All of these studies utilized a bipolar, bilateral thoracoscopic approach. Outcomes with unipolar ablative energy sources have not shown the same consistency in freedom from AF, with success ranging from 36.8% to 88.9%.[12-16]

In general, the safety of a hybrid surgical approach has been well demonstrated with a periprocedural mortality rate less than 1%.[17] However, major complications have occurred in some series, including conversion to sternotomy due to bleeding, cerebral vascular accident, aortoesophageal fistula, and late sudden cardiac death.[9,13,18] A bilateral thoracoscopic approach is most common with the hybrid procedure, although unilateral right thoracoscopic and subxiphoid access also have been utilized.[19] Pulmonary vein isolation is performed uniformly, with additional lesions sets varying widely. Catheter ablation can be performed either concurrently[13] or later, whether during the index hospitalization[8] or several weeks post-surgical ablation.[14,15]

Two ongoing clinical trials investigating the hybrid approach will be forthcoming. The Staged Transthoracic Approach to Persistent Atrial Fibrillation (TOP-AF) may shed further light on the ideal approach to minimally invasive surgical management of atrial fibrillation.[20] This 2:1 randomized controlled trial in patients with persistent AF will compare percutaneous catheter ablation vs surgical ablation to create a box lesion isolating the pulmonary veins, followed by reevaluation at 3 months with the option of a staged procedure. In addition, the Dual Epicardial Endocardial Persistent Atrial Fibrillation Study (DEEP AF) will evaluate the efficacy of the approach as described herein and includes patients with persistent AF or LSPAF.[21] The study has now completed feasibility phase, and the pivotal trial is underway.

Conclusion

During the last 5 years, there has been increasing interest in hybrid approaches to AF management. Study results are promising despite the lack of randomized data, with a demonstrated high margin of safety and excellent short-term results albeit with a steep learning curve. With more rigorous study and longer-term follow-up, the hybrid approach may prove to be the standard of care for persistent atrial fibrillation in the future.

Conflict of Interest Disclosure: Dr. Ailawadi is a consultant for Abbott Laboratories, Edwards Lifesciences Corp, St. Jude Medical, and Atricure, Inc.
Keywords: atrial fibrillation, hybrid, ablation, minimally invasive

References

1. Gage BF, Waterman AD, Shannon W, Boechler M, Rich MW, Radford MJ. Validation of clinical classification schemes for predicting stroke: results from the National Registry of Atrial Fibrillation. JAMA. 2001 Jun 13;285(22):2864-70.
2. Lip GY, Tse HF, Lane DA. Atrial fibrillation. Lancet. 2012 Feb 18;379(9816):648-61.
3. Cox JL, Boineau JP, Schuessler RB, et al. Successful surgical treatment of atrial fibrillation. Review and clinical update. JAMA. 1991 Oct 9;266(14):1976-80.
4. Ramlawi B, Abu Saleh WK. Surgical Ablation of Atrial Fibrillation. Methodist Debakey Cardiovasc J. 2015 Apr-Jun;11(2):1040-8.
5. Melby SJ, Schuessler RB, Damiano RJ Jr, et al. Ablation technology for the surgical treatment of atrial fibrillation. ASAIO J. 2013 Sep-Oct;59(5):461-8.
6. Wolf RK, Schneeberger EW, Osterday R, et al. Video-assisted bilateral pulmonary vein isolation and left atrial appendage exclusion for atrial fibrillation. J Thorac Cardiovasc Surg. 2005 Sep;130(3):797-802.
7. January CT, Wann LS, Alpert JS, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol. 2014 Dec 2;64(21):e1-76.
8. Mahapatra S, LaPar DJ, Kamath S, et al. Initial experience of sequential surgical epicardial-catheter endocardial ablation for persistent and long-standing persistent atrial fibrillation with long-term follow-up. Ann Thorac Surg. 2011 Jun;91(6):1890-8.
9. Krul SP, Driessen AH, van Boven WJ, et al. Thoracoscopic video-assisted pulmonary vein antrum isolation, ganglionated plexus ablation, and periprocedural confirmation of ablation lesions: first results of a hybrid surgical-electrophysiological approach for atrial fibrillation. Circ Arrhythm Electrophysiol. 2011 Jun;4(3):262-70.
10. La Meir M, Gelsomino S, Lucà F, et al. Minimally invasive surgical treatment of lone atrial fibrillation: early results of hybrid versus standard minimally invasive approach employing radiofrequency sources. Int J Cardiol. 2013 Aug 20;167(4):1469-75.
11. Pison L, La Meir M, van Opstal J, Blaauw Y, Maessen J, Crijns HJ. Hybrid thoracoscopic surgical and transvenous catheter ablation of atrial fibrillation. J Am Coll Cardiol. 2012 Jul 3;60(1):54-61.
12. La Meir M, Gelsomino S, Lorusso R, et al. The hybrid approach for the surgical treatment of lone atrial fibrillation: one-year results employing a monopolar radiofrequency source. J Cardiothorac Surg. 2012 Jul 19;7:71.
13. Gehi AK, Mounsey JP, Pursell I, et al. Hybrid epicardial-endocardial ablation using a pericardioscopic technique for the treatment of atrial fibrillation. Heart Rhythm. 2013 Jan;10(1):22-8.
14. Bisleri G, Rosati F, Bontempi L, Curnis A, Muneretto C. Hybrid approach for the treatment of long-standing persistent atrial fibrillation: electrophysiological findings and clinical results. Eur J Cardiothorac Surg. 2013 Nov;44(5):919-23.
15. Muneretto C, Bisleri G, Bontempi L, Curnis A. Durable staged hybrid ablation with thoracoscopic and percutaneous approach for treatment of long-standing atrial fibrillation: a 30-month assessment with continuous monitoring. J Thorac Cardiovasc Surg. 2012 Dec;144(6):1460-5.
16. Zembala M, Filipiak K, Kowalski O, et al. Minimally invasive hybrid ablation procedure for the treatment of persistent atrial fibrillation: one year results. Kardiol Pol. 2012;70(8):819-28.
17. Je HG, Shuman DJ, Ad N. A systematic review of minimally invasive surgical treatment for atrial fibrillation: a comparison of the Cox-Maze procedure, beating-heart epicardial ablation, and the hybrid procedure on safety and efficacy. Eur J Cardiothoracic Surg. 2015 Oct;48(4):531-41.
18. Lee HM, Chung SR, Jeong DS. Initial experience with total thoracoscopic ablation. Korean J Thorac Cardiovasc Surg. 2014 Feb;47(1):1-5.
19. Gelsomino S, Van Breugel HN, Pison L, et al. Hybrid thoracoscopic and transvenous catheter ablation of atrial fibrillation. Eur J Cardiothorac Surg. 2014 Mar;45(3):401-7.
20. Pragliola C, Mastroroberto P, Gaudino M, Chello M, Covino E. Staged transthoracic approach to persistent atrial fibrillation (TOP-AF): study protocol for a randomized trial. Trials. 2014 May 26;15:190.
21. ClinicalTrials.gov [Internet]. Bethesda, MD: U.S. National Institutes of Health. Dual Epicardial Endocardial Persistent Atrial Fibrillation (AF) Study (DEEP); 2010 Nov 22 [accessed 2015 Nov 2]. Available at: https://clinicaltrials.gov/ct2/show/NCT01246466.