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The Convergent Procedure is a Collaborative Atrial Fibrillation Treatment

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ABSTRACT. A 43-year-old man with a 10-year history of persistent atrial fibrillation (AF) who had failed medical treatment with cardioversion while on class III antiarrhythmic medication presented with persistent and symptomatic AF. Transthoracic echocardiogram demonstrated left atrial size of 7.0 cm and left ventricular ejection fraction of 40%. The patient underwent combined and simultaneous endocardial and epicardial AF ablation (Convergent procedure). He was discharged 3 days later and returned to full activity in 2 weeks. At 12 months, he remained in sinus rhythm by 24-hour Holter monitor without antiarrhythmic medication or anticoagulation, his left atrial size was 4.5 cm and his left ventricular ejection fraction was 55%. He remains in sinus rhythm at 22 months. The Convergent procedure, a collaboration between a surgeon and an electrophysiologist, is an innovative way to provide effective treatment of patients with chronic atrial fibrillation. This convergence of technologies and expertise allows: 1) the creation of a complete, bi-atrial, endocardial, and epicardial ablation pattern without a chest incision or cardiopulmonary bypass; 2) provides intraoperative metrics to confirm procedural success; 3) encourages integrated patient care by cardiac surgery and electrophysiology; and 4) potentially decreases length of hospital stay and the number of repeat ablation procedures.

KEYWORDS. ablation therapy, arrhythmia surgery, atrial fibrillation, hybrid procedure, minimally invasive.

ISSN 2156-3977 (print)
ISSN 2156-3993 (online)

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Rhythm Management

Introduction

Persistent and longstanding persistent atrial fibrillation (AF) remain difficult to successfully treat with medications, catheter ablation, or minimally invasive surgical procedures alone. Treating chronic AF with a limited ablation pattern, which does not segment the atria into small enough sections, has low success. The creation of a

comprehensive and bi-atrial lesion pattern, with appropriate placement of transmural ablations, is imperative to interrupt sustainable AF circuits and to prevent new circuits from developing.

The Cox Maze III procedure¹ blocks the transmission of ectopic pulmonary vein foci and interrupts the macro-re-entrant atrial pathways that perpetuate AF, but it is a complex operation seldom performed. Minimally invasive procedures like the “mini-maze”² and epicardial pulmonary vein isolation³ reduce procedural complexity by eliminating cardiopulmonary bypass but also decrease the number of lesions. The endocardial, catheter-based ablations, not unlike the surgical procedures, remain long and technically difficult procedures. The high rate of repeat procedures and mediocre outcomes after catheter ablation are disappointing.⁴ Only a comprehensive lesion pattern has demonstrated acceptable long-term outcomes for persistent AF.

Dr. Kiser reports he is a stockholder of nContact Surgical. Dr. Mounsey reports he is a consultant to Boston Scientific Inc., Medtronic, and St. Jude Inc.; Dr. Mounsey also reports he is a paid speaker for each of these companies. None of these companies provided financial support for this project. The authors thank Margaret Alford Cloud for editorial assistance.

Manuscript received March 29, 2011, final version accepted April 15, 2011.

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Less invasive surgical ablation procedures use various energy sources to create an anatomical pattern of myocardial scar that attempt to divide the atria into non-conductive segments and disrupt the re-entry circuits which cause AF.^{5,6} Electrophysiologists use percutaneously placed catheters for endocardial ablative therapy to eliminate foci of abnormal electrical activity and to create a pattern of scar within the atria. Both surgical and endocardial ablative therapies for AF have less than desirable outcomes when treatment is limited to the left atrium or in those patients with increased left atrial size.^{7,8} Unfortunately, surgeons and electrophysiologists seldom collaborate in the development of new technologies and innovative approaches to overcome their procedural shortcomings.

Pericardioscopy provides endoscopic access to and visualization of the beating epicardial surface via the central tendon of the diaphragm without the need for cardiopulmonary bypass or chest incisions.⁹ This unique access can be safely performed in a hybrid suite outside the operating room and has enabled a co-disciplinary epicardial and endocardial ablation pattern, termed the Convergent procedure.¹⁰

The Convergent procedure is the simultaneous creation of the surgeon's epicardial ablation pattern and the electrophysiologist's endocardial ablation pattern. The surgeon's ability to effectively create robust and visible epicardial ablation lines greatly reduces the amount of endocardial tissue which must be ablated to complete a comprehensive and bi-atrial pattern. The Convergent pattern includes pulmonary vein isolation; coronary sinus ablation; mitral annulus ablation; posterior left atrial ablation; and ablation of the cavotricuspid isthmus. The integration of a surgeon's anatomical approach to AF with the physiological approach of the electrophysiologists has led to the development of the convergent procedure.

Pericardioscopic Convergent procedure

During the procedure, the patient is positioned supine under single-lumen, general endotracheal anesthesia in a "hybrid electrophysiology/operating room suite" with integrated fluoroscopy, endoscopy, and CARTO (Biosense Webster, Inc. Diamond Bar, CA) or EnSite NaVx (St Jude Medical, St Paul, MN) imaging technologies. With abdominal laparoscopy and endoscopy (Karl Storz Endoscopy, Tuttlingen, Germany), the central fibrous region of the diaphragm and the pericardium directly behind the diaphragmatic incision is opened horizontally, providing access to the posterior region of the heart.

A pericardioscopic cannula positioned through a subxyphoid incision and into the pericardium (**Figure 1**) provides endoscopic visualization and access to the left atrium, coronary sinus, the superior (SVC) and inferior (IVC) vena cava, the aorta, the right main pulmonary artery, the right and left pulmonary veins, the transverse sinus, the ligament of Marshall, and the left and right atrial appendages. There is minimal compromise of cardiac function during pericardioscopy.

Figure 1: Position of pericardioscopic cannula thorough the abdomen and into the pericardial space behind the left atrium.

The endocardial and epicardial ablation lines of the Convergent procedure create a comprehensive, bi-atrial lesion pattern (**Figure 2**). The blue lines depict lines of ablation easily performed utilizing pericardioscopy. Anatomic restrictions and limitations of existing energy sources to consistently create transmural and contiguous lesions prevent a totally epicardial procedure. Endocardial ablation lines (green) are necessary to complete the contiguous pattern. The endocardial ablation eliminates residual gaps of viable and electrically active myocardium thereby supplementing the epicardial procedure from within the left and right atrium. These additional endocardial lesions resolve deficiencies of the minimally invasive surgical ablation procedure.

Surgical portion of the Convergent procedure

The surgeon's goal is to electrically isolate the posterior left atrium and to ablate the pulmonary veins and the ligament of Marshall while recognizing and limiting the potential for thermal injury of adjacent mediastinal structures. There is not an existing energy source or surgical access that enables the surgeon to complete a comprehensive pattern of contiguous and transmural

Figure 2: Convergent Procedure lesion pattern.

lesions from the surface of the beating heart. During the Convergent procedure, unipolar radiofrequency energy (Visitrax, nContact Surgical, Morrisville, NC) is used.

Lesion #1—posterior left superior to right superior pulmonary vein lesion

At the cephalad reflection of the pericardium near the dome of the left atrium, a lesion is created which extends along the pericardial reflections between the left and right superior pulmonary veins on the posterior left atrium.

Lesion #1a—posterior left inferior to right inferior pulmonary vein lesion

A lesion is created at the junction of the left atrium and left ventricle near the coronary sinus which extends between the left and the right inferior pulmonary veins on the posterior left atrium.

Lesions #2—posterior left superior to left inferior pulmonary vein lesion

A lesion is created on the posterior pulmonary vein antrum between the left superior and left inferior pulmonary veins which is contiguous with lesions #1 and #1a.

Lesions #2a—posterior left inferior pulmonary vein to coronary sinus lesion

A continuation of lesion #2, lesion 2a is created extending from the left inferior pulmonary vein antrum to the coronary sinus.

Lesion #3—posterior right superior to right inferior pulmonary vein lesion

A lesion is created on the posterior pulmonary vein antrum between the right superior and right inferior pulmonary veins. This lesion completes the electrical isolation of the posterior left atrium.

Lesions #3a—posterior right inferior pulmonary vein to IVC lesion

A continuation of lesion #3, lesion 3a extends across the oblique sinus and onto the IVC. This lesion is created to the level of the diaphragm, when feasible.

Lesions #4—posterior right inferior pulmonary vein to right atrium lesion

A second lesion is created as a continuation of lesion #3 which extends from the right inferior pulmonary vein, across the oblique sinus, and onto the right atrium toward the area where the coronary sinus enters the right atrium.

Lesion #5—anterior right pulmonary vein lesion

With the cannula between the right atrium and the right pericardium, a lesion is created which extends from the right pulmonary artery across the anterior right superior and inferior pulmonary veins.

Lesion #6—ablation of the epicardial fat at Waterston's groove

A second lesion is created which parallels lesion #5 in the interatrial (Waterston's) groove. This lesion ablates the epicardial fat between the left and right atria at the lateral interatrial septum and may eliminate nearby ganglionated plexi. For those patients with bi-atrial enlargement, this lesion may be extended well onto the right atrium.

Lesion #7—anterior left pulmonary vein lesion

Using a guidewire positioned through the transverse sinus, behind the left atrial appendage, and along the anterior left pulmonary veins as a guide (Figure 3), a lesion is created along the anterior left pulmonary veins that intersects the posterior left pulmonary vein lesion (#2). This lesion is extended behind the left atrial appendage and anterior to the left superior pulmonary vein.

Lesion #7a—ligament of Marshall

The guidewire guides the ablation device behind the left atrial appendage to ablate the ligament of Marshall and the dome of the left atrium within the transverse sinus.

Electrophysiology portion of the Convergent procedure

Without interruption, the operative suite becomes an electrophysiology laboratory and percutaneous intravascular access allows placement of two trans-septal sheaths.

Figure 3: Position of guidewire during the Convergent procedure.

Interrogation of the four pulmonary veins (lesions #8,#9,#10)

A circular, multipolar, mapping catheter (Lasso, BiosenseWebster, Diamond Bar, CA) is positioned into the individual pulmonary veins. Radiofrequency ablation using a saline cooled ablation catheter (Thermacool, BiosenseWebster; Cool Path, St Jude Medical; Chilli, Boston Scientific, Natick, MA) is directed at the remaining electrical activity until each of the pulmonary veins are electrically isolated. Entrance and exit block is confirmed at each vein.

Interrogation of the posterior left atrium

The Lasso catheter is then used to interrogate the endocardial posterior left atrium to confirm electrical silence with the "box" between lesions 1, 1a, 2, and 3.

Mitral annular line (lesion #2b)

A line is ablated from the left inferior pulmonary vein to the mitral annulus to complete a mitral annular line of block.

Debulking of the coronary sinus (lesions #12 and #12a)

The muscular fiber connections from the left atrium into the coronary sinus are debulked along the endocardial aspect of the left atrium (lesion #12) from the posterior septum laterally on the mitral annulus. After completion of all left sided lesions, one of the sheaths is withdrawn into the right atrium and lesion #12a is created by ablating within the coronary sinus from the lateral end to the coronary sinus os.

Ablation of the cavotricuspid isthmus (#11)

An ablation line of block is created from the tricuspid annulus to the inferior vena cava at approximately the 6 o'clock position on the cavotricuspid isthmus.

Cardioversion and interrogation of ablation pattern

When necessary, cardioversion to normal sinus rhythm is performed. Rapid atrial pacing and atrial extra-stimulus is performed in the baseline state and with isoproterenol (Sanofi-Aventis, Bridgewater, NJ). Induced arrhythmias, such as atrial flutter or atrial tachycardia, are mapped and ablated.

Upon completion of the endocardial portion of the Convergent procedure, a drain is placed in the pericardial space and routed through the left 5-mm incision and the midline fascia is closed securely with non-absorbable, interrupted suture and the skin closed routinely. The patient is generally extubated in the operating room and is usually ready for discharge in 36–72 h. Using an Enoxaparin (Sanofi-Aventis) bridge, Warfarin (Bristol-Myers Squibb, New York, NY) therapy is initiated the night of the procedure and continued at least 3 months. Antiarrhythmic medications are initiated at the discretion of the electrophysiologist but are discontinued by

3 months. The patients are evaluated at 1, 3, 6, and 12 months with routine electrocardiogram (ECG) evaluation and with a 24-h Holter before the end of the first 3-month postoperative period. Seven-day, or longer, monitoring is requested at the 6- and 12-month visits and annually thereafter.

Outcomes

To date, the authors have treated 67 patients using the Convergent procedure. The average procedure time was 328 min and the average fluoroscopy time was 37.4 min. Of the 20 patients who had 24-h Holter monitor data available at 12 months, 16 (90%) were in sinus rhythm. One patient underwent the Convergent procedure and, simultaneously, had minimally invasive mitral valve repair via a 7-cm right submammary incision and was in sinus rhythm at 18 months. Two patients developed a pericardial effusion 2 weeks post procedure that required percutaneous drainage. Both recovered fully and remained in sinus rhythm at 12 months. No hemodynamically significant pericardial effusions have occurred since drainage of the pericardium post procedure became standard. One patient, discharged on Dofetilide (Pfizer, New York, NY), suffered sudden cardiac death 7 days post procedure. This was undoubtedly due to torsades de pointes as no procedure-related cause of death was discovered at autopsy. One patient developed a fatal atrial-esophageal fistula 10 days post procedure and one patient moved and has been lost to follow-up.

Discussion

The case described was difficult to treat due to left atrial enlargement and the duration of AF. The success of any surgical treatment for persistent or longstanding persistent AF is dependent upon the transmural and contiguity of the ablation lines and the completeness of the lesion pattern. The inability to obtain a high degree of success with the current minimally invasive surgical approaches or the percutaneous catheter approaches has led us to the Convergent procedure. This multidisciplinary approach integrates the advantages of both cardiac surgery and electrophysiology. Without sternotomy or cardiopulmonary bypass, we are able to create and evaluate a comprehensive bi-atrial ablation pattern important in the successful treatment of AF. The surgeon is able to access the epicardial space and effectively create wide, long ablation lines that significantly reduce the degree of endocardial ablation required to complete an endocardial AF ablation. The electrophysiologists are able to verify that the pulmonary veins are electrically silent, that the posterior left atrium is electrically isolated, and they can successfully create lesions at the coronary sinus, the mitral valve annulus, and at the cavotricuspid isthmus without cardiectomy. This collaboration between the surgeon and the electrophysiologists is an innovative way to provide an effective treatment to patients with chronic atrial fibrillation.

This convergence of technologies and expertise allows: 1) the creation of a complete, bi-atrial, endocardial and epicardial ablation pattern without a chest incision or cardiopulmonary bypass; 2) provides intraoperative metrics to confirm procedural success; 3) encourages integrated patient care by cardiac surgery and electrophysiology; and 4) potentially decreases length of hospital stay and the number of repeat ablation procedures.

Although the results are encouraging, the number of patients evaluated remains small. The development of symptomatic pericardial effusions, perhaps directly related to the degree of pericardial irritation combined with immediate anticoagulation, has been addressed successfully by draining the pericardium for 36 h. The risk of atrial-esophageal fistula associated with the use of radiofrequency energy requires continued evaluation. The use of esophageal temperature probes and pericardial irrigation with cool saline may reduce the risk of this complication, but ongoing evaluation is mandatory. Pericardioscopy is early in development, requiring appropriate initial training and guidance, but can be quickly mastered by surgeons with minimally invasive procedural experience. Careful evaluation of outcomes and procedural proficiency are crucial to the long-term success of this new hybrid approach to chronic AF.

Collaboration between specialists is the key to procedural success and patient satisfaction. The development of a multidisciplinary team of physicians who communicate during patient evaluation and treatment planning and have a support staff to coordinate follow-up care demonstrates a commitment to restore normal sinus rhythm. This unified commitment fosters program growth and procedural success. The case we have presented represents the successful collaboration of medical specialists around a difficult clinical situation and a grateful patient who, even today, remains connected to his team of providers. Therefore, the Convergent procedure is not only a co-disciplinary procedure, but also a collaborative effort. By integrating cardiac surgery and electrophysiology in a "hybrid" AF

treatment, new procedural and perioperative standards have been established. The outcomes utilizing this multidisciplinary approach are excellent in the persistent and long-standing persistent AF population.

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