Minimally Invasive Vertical Approach for the Surgical Treatment of Lone Atrial Fibrillation

- Pulmonary Vein Isolation
- Lesion Testing
- Autonomic Ganglia Ablation
- Left Atrial Appendage Amputation

A Flexible Approach to a Proven Technique

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# Surgical Technique for the Treatment of Lone Atrial Fibrillation

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INTRODUCTION

Lone Atrial Fibrillation: What is it?

Lone AF is defined as AF without any underlying heart disease. Our average patient population with lone AF has been approximately 65–70 years old. Today it is believed that up to 45% of the patients with AF have lone atrial fibrillation.¹

Advances in technology and techniques are allowing cardiac surgeons to offer multiple treatment modalities for atrial fibrillation (AF). Product and procedural advancements continue to make it easier for surgeons to offer the right procedure for the right patient. To that end, we describe our experience using the beating heart bilateral access surgical approach in the treatment of lone AF. This monograph depicts bilateral thoracotomies which are used for direct visualization and for introducing endoscopic tools. Surgeons with extensive stand-alone ablation experience or other minimally invasive VATS (video assisted thoracic surgery) experience may elect to use only port-sized incisions to accomplish the procedure in a totally endoscopic fashion.

Current Therapies

Non-surgical therapies include:

- Pharmaceutical Treatment of AF: Of all the drugs prescribed for AF patients, anticoagulation therapy has been consistently proven to reduce mortality and morbidity; however the risks of these medications, as well as patient reluctance to take them, are well known.¹

- EP Therapy: Catheter-based ablations are becoming more frequent because of their minimally invasive nature and no need for general anesthetic. However, complications do exist, including pericardial effusion and tamponade secondary to esophageal perforation, stroke and transient ischemic attacks, pulmonary vein stenosis, sinus node dysfunction, and esophageal perforation, which has been reported as high as 1%.² Some of the limitations of the percutaneous ablation include achieving transmurality and continuity of the ablation lines, and prolonged procedural time, sometimes up to 5 hours.³

Surgical therapies include:

- Full sternotomy: beating heart and arrested heart procedures
- Minimally invasive arrested heart procedure
- Minimally invasive beating heart bilateral thoracotomy procedures
- Minimally invasive beating heart bilateral port access procedures

We’ve adopted both bilateral approaches because they are relatively easy, utilize standard surgical skills, have minimal morbidity, and have excellent success rates. During our surgical experience to date with minimally invasive surgery for lone AF, 92% of our Paroxysmal AF patients were in Normal Sinus Rhythm at their 6-month follow-up. In addition, we have not had to convert any patients to an “open” procedure.

Note: This document is based on the experience and techniques of doctors Reiter and Beyer at Scott & White Hospital. Results may vary.
Potential Benefits of Minimally Invasive Surgery for Lone AF

- Expected reduced procedural time compared to catheter ablation
- No fluoroscopy
- No drug related side effects
- Direct visualization (if using mini-thoracotomies)
- Uses traditional surgical principles
- Allows removal of Left Atrial Appendage (LAA)
- Addresses multiple potential mechanisms of AF: Autonomic ganglia (AG), ectopic foci and the Ligament of Marshall

The reader of this monograph should understand the indications, contraindications and expected goals of pulmonary vein isolation in a minimally invasive approach. Surgeons should be familiar with the anatomy of these approaches. Because this approach is different than the open sternotomy approach, we highly recommend that each surgeon perform “open” procedures using the expected devices until they are proficient in their use and understand their applications and limitations.

Clinical Details of Performing a Lone AF Procedure

Indications:
- Paroxysmal Atrial Fibrillation, refractory to medications

*Note: We have successfully treated patients who have had previous AV nodal ablation and pacemaker implantation.*

Contraindications
- Prior cardiac surgery
- Pleural disease, pericardial adhesions
- Left atrial thrombus
- Left atrium larger than 5.5 cm (relative)

Pre-Operative Planning
- Chest X-ray, recognizing any pulmonary pathology demonstrating complex/extensive lung adhesions or inability to perform single lung ventilation.
- Evaluation of EKG for preoperative arrhythmias and underlying function of the SA node when the patient is not in AF.
- Echocardiogram evaluation prior, to determine LA size, which also helps in defining any structural valve anomalies. This can be trans-thoracic during pre-operative workup but must include intra-operative TEE as well. Presence of thrombus in the left atrial appendage will abort the minimally invasive procedure. The patient’s medications will be re-examined and they will be reconsidered for the procedure in one month.
- Stress test, then coronary angiography, as warranted.
- Patient education concerning possible need for cardioversion(s) and expectation to continue medications during the post-operative period and likelihood of experiencing alternating sinus rhythm and atrial fibrillation.
- Type and cross of 4 units PRBC, antibiotic of choice, if on Coumadin*, discontinue 4 days prior to admission, start heparin IV day of admission, 1 day prior to surgery.
Intra-Operative Instrumentation

Standard open heart instrumentation with available cardiopulmonary bypass is required.

### Specific additional/important instruments and disposables:

- Endoscopic instruments: grasper, scissors, needle driver and kitners
- Endo GIA Universal Stapling System** with “green” load
- Soft tissue retractor, large and medium available
- Pediatric metal.yankauer
- 30° scope (5 or 10 mm)
- 5 or 12 mm port (for scope)
- Long bovie
- Cardioblate® Navigator™ Tissue Dissection Device
- Cardioblate® Gemini™-x Surgical Ablation Device (bipolar)
- Cardioblate® MAPS Device (monopolar ablation; bipolar pacing, stimulation, sensing)
- Temporary pacing wires
- Blake drainage tubes
- Pediatric internal defibrillator paddles
- External defibrillator pads (R-2 pads)
- “Sponge on a stick”
- Inlet*** Medical CloSure*** Device
- Medtronic 5388 temporary pacemaker
- Medtronic 2090 Analyzer (if desired)

As mentioned previously, we utilize the Medtronic dissection device and irrigated RF ablation system (Cardioblate® Gemini™-x device) to facilitate this procedure. The Cardioblate® Navigator™ dissector is easily articulated and controlled with one hand; in addition, we have found the ability to control the light (on/off) to be an advantage over other dissectors in facilitating this non-sternotomy procedure. For ablation, our own personal preference is to use the Cardioblate® Gemini™-x bipolar device because the design of the neck allows us a great deal of flexibility in terms of choosing a “top down” or “bottom up” approach on either side in order to accommodate patients’ differing heart anatomies. The procedure is supported by our use of the Cardioblate® MAPS device as described later in the document.

### Patient Positioning, Anesthesia and TEE

The procedure begins with the patient in the left lateral decubitus position with the right arm in the “swimmer’s” position. The elbow should be positioned close to the patient’s ear, which aids in allowing the operating surgeon a “wide” line of site into the small thoracotomy wound. The patient is turned upon completion of the right sided procedure into a right lateral decubitus position with the left arm in the “swimmer’s” position. Having the arm over the head aids in spreading the inter-costal spaces; other than the soft tissue retractor, no other retractor is required.

**Additional measures include:**

- Pulmonary embolism prophylaxis: Using both anti-embolism stockings and sequential compression stockings.
- Invasive monitoring and EKG: radial artery line, central venous line, intravenous access, Foley catheter.
- External defibrillation pads: The anterior pad is initially placed on the left pectoralis, then re-positioned when the patient is re-positioned, placing it upon the right pectoralis region.
- General anesthesia with a double lumen endotracheal tube.
- TEE is performed and the probe is removed once atrial thrombus has been ruled out.
- If a patient has a pacemaker, it is left on; defibrillators are turned off.
Anatomy, Dissection, Ablation and Lesion Assessment

The procedure begins with anesthesia selectively ventilating the left lung only. A 5 mm port is placed into the right 6th or 7th inter-costal space (ICS) at the intersection of the anterior axillary line and xiphoid process. The 30° scope is inserted and the surgeon assesses the thorax for access, adhesions and the ability to visualize the right phrenic nerve. Eight to 15 mmHg of insufflation is applied once the 5 mm port is inserted. The mini-thoracotomy incision is performed in the 4th ICS and measures approximately 4-5 cm in length, starting just lateral to the pectoralis major. ICS is confirmed with camera visualization.

A soft tissue retractor is placed and the right pericardium and phrenic nerve can be easily visualized with direct vision and with the camera.

Using endoscopic instruments directly through the thoracotomy incision, the pericardium is opened (Fig. 1). Using the endo-shears and bovie, the pericardotomy is made 1-2 cm anterior of the phrenic nerve and the incision is carried superiorly to expose the superior vena cava and inferiorly to expose the inferior vena cava. Pericardial retraction sutures are placed in the posterior edge of the pericardium for lateral retraction (Fig. 2). The sutures are pulled through the chest wall from a posterior and lateral position using the Inlet Medical CloSure*** device. This will offer excellent exposure of the posterior-lateral heart and aids in retraction of the non-ventilated lung. These sutures are secured externally with hemostats. A suture may be placed in the dome of the diaphragm for caudal traction if needed to visualize the oblique sinus with the suture exiting via the camera port. A “sponge on a stick” is an excellent method to help displace the heart while placing these sutures or during dissection.

At times the pericardial fat can limit visualization of the phrenic nerve; it is important to carefully reflect the pericardial fat, starting higher than the anticipated pericardotomy, to allow the fat to fall posteriorly and to allow direct vision of the nerve. Visualization of the phrenic nerve is mandatory.
Fig. 1
The pericardium is opened 1-2 cm anterior to the phrenic nerve.

Fig. 2
Retraction sutures are placed and secured externally with hemostats.
Using direct and camera visualization, the oblique sinus is accessed with either an endo-kitner or pediatric metal yankauer; these instruments will help develop a plane between the right inferior pulmonary vein and IVC. The same method(s) are used to develop a plane between the right superior pulmonary vein and right pulmonary artery. The Cardioblate® Navigator™ dissector offers blunt dissection with a luminous omni-directional tip and the ability to pass a guide for future placement of a catheter and the bipolar ablation device. The Navigator™ dissector is introduced into the thorax via an 8 mm working port approximately 1-2 cm lateral of the camera port in the same ICS. Once the tip has entered the oblique sinus, it is gently curved superiorly behind the right pulmonary veins (Fig. 3) and advanced until resting within the transverse sinus; advancing too far superiorly will encounter the pulmonary artery which should be avoided! Frequently a veil of tissue obstructs the transverse sinus and an endo-kitner can gently dissect the tissue off the tip of the Navigator™ device.

Once the tip exits the transverse sinus, increase the curve of the Navigator™ device tip slightly so the tip is now actually pointing inferiorly. Gently advance the supplied guidewire through the center channel of the Navigator™ dissector and use an endo-instrument to grasp it as it exits the tip of the Navigator™ device (Fig. 4). Pull the tip out of the incision for attachment to the atraumatic guide, supplied with the Gemini™-x ablation device.
Fig. 3
The Navigator™ dissector is advanced through the oblique sinus into the transverse sinus behind the right pulmonary veins.

Fig. 4
The supplied guidewire is advanced through the center channel of the Navigator™ device and is pulled out of the thoracotomy after exiting the tip of the dissector.
Attach the Gemini™-x guide to the end of the guidewire (using the small locking device) by feeding the guidewire approximately 2 cm into the guide and turning it clockwise to tighten and secure the two together (Fig. 5b). Under visualization, pull the guidewire gently from the rear of the Navigator™ device. When the tip of the guide is approximately 1 mm from the tip of the Navigator™ dissector, lock the guidewire into the Navigator™ device by tightening the guide lock on the Navigator™ handle. Ensure that this connection is secure, and then pull the guide into place behind the pulmonary veins by carefully retracting the Navigator™ device (the gap between the guide and device is eliminated by allowing it to straighten during removal from behind the pulmonary veins) (Fig. 5a). Monitor the area where the guide attaches to the tip of the Navigator™ dissector in order to avoid possible snagging of tissue; continue pulling gently, never using force. Snap the posterior jaw of the Gemini™-x device to the end of the guide coming out from the port incision (Fig. 6b). Introduce the Gemini™-x ablation device through the incision (Fig. 6a) and into the desired ablation position by gently pulling the guide from its other end (coming out the mini-thoracotomy).

The end of the guide and tip of the posterior jaw of the bipolar device should be visualized exiting the sinus opposite of that which was first entered. Now the bipolar jaws need to be placed upon the atrial wall (antrum) to prevent ablation of the pulmonary veins. Note: The Gemini™-x ablation device can be placed with a superior-to-inferior approach as shown in (Fig. 7).

**CLINICAL PEARL**

With the Gemini™-x device, we prefer an inferior approach to the pulmonary veins on both the right side and left side. These angles are more conducive to pulling the Gemini™-x device into place. Fortunately, the Gemini™-x device versatility allows both a superior or inferior approach on either side, depending upon patient variability and surgeon preference. Note that an inferior approach for the Gemini™-x device requires a slightly larger incision than that needed for the dissector.
Fig. 6a and 6b
The posterior jaw of the Gemini™-x device is secured to the guide exiting the port-sized incision. The ablation device is then inserted into the chest cavity and is advanced to the pulmonary veins by gently pulling the other end of the guide, which is exiting the mini-thoracotomy.

Fig. 7
The Gemini™-x jaws are placed around the right pulmonary veins using an inferior-to-superior or superior-to-inferior approach. Once the electrode surface is visualized (confirming the tips across the PVs), ablation can commence.
When the tips of the electrodes are seen to be across the PVs, close and lock the jaws, and commence ablation. Ablation more than once in the same plane is not required, although opening the device and using the "sponge on a stick" to herniate some epicardial fat into the open jaws allows for ablation of the autonomic ganglia nearest the pulmonary veins. Recognize and avoid the area of the Sino-Atrial node.

Testing the lesions is strongly recommended and considered an integral component of the procedure. When testing the lesions, leave the jaws of the Gemini™-x device open but in place around the pulmonary veins. The Cardioblate® MAPS device can be employed. Use a rate of 20 beats greater than the patient’s intrinsic rate, double the capture threshold, and stimulate no less than 1 centimeter away from the visible lesion. Lack of capture ensures electrical isolation. Remove, or re-ablate and then remove, the Cardioblate® Gemini™-x device.

The Cardioblate® MAPS device is used to help locate and ablate the autonomic ganglia (Fig. 8). Using a temporary pacemaker, burst atrial pacing rates of 800 bpm are used to recognize areas of autonomic ganglia. When stimulated, transient A-V block is induced and the correlating AG is identified. The Cardioblate® MAPS device is then used to ablate the suspected area. Re-testing will confirm success in terms of being unable to reproduce the A-V block.

When the autonomic ganglia around the right pulmonary veins are identified and ablated. The inset shows ablation of the left pulmonary vein autonomic ganglia, which is performed later in the procedure.
Atrial temporary pacing wires are placed into the pericardium over the right atrium, which decreases the risk of bleeding upon removal post-operatively while maintaining adequate contact for pacing as needed. After assessment for any bleeding, we then place a Blake drainage tube along the hilum. The thoracotomy can be closed or left open at the surgeon’s discretion.

The patient is re-positioned, the anterior external defibrillation pad is also re-positioned, and the patient is re-draped.

The left sided ablation is quite similar to the right with the following exceptions. The thoracotomy incision is slightly more posterior. If the anatomy permits, the pericardotomy is made posterior to the phrenic nerve; this is carried inferior to the diaphragm and superior to the left pulmonary artery. With minimal dissection and manipulation, the ligament of Marshall can be identified (Fig. 9). The ligament can be dissected with electrocautery, or ablated with the Cardioblate® MAPS device. Care is exercised not to ablate any structure(s) beyond the ligament itself. Infrequently, a remnant of vein may exist, creating some bleeding that will need to be addressed. The Navigator™ device is placed posterior to the LPVs (Fig. 10). Using the guidewire, the guide is positioned and the Gemini™-x device is placed using a inferior-to-superior approach. Note: The Gemini™-x device can also be placed using a superior-to-inferior approach. Lesion testing is repeated with the MAPS device.
Left Atrial Appendage

Using minimal, gentle manipulation, the left atrial appendage is grasped at its base with an endo-stapler with a green load. The stapler should be closed into position only once and fired without any twisting or pulling of the device (Fig. 11). Any remnant of the appendage should be addressed with either an endo-loop or a large hemoclip. Firing a second stapler should be avoided.

Closure of Wounds, Drains and Pain Management

The chest is examined for any bleeding and a Blake drain is placed. The typical thoracotomy closure can be performed if desired.

Prior to extubation, patients remaining in AF are cardioverted in the OR.

Fig. 11
The LAA is resected using an endo GIA stapler.
Post-Operative and Discharge Intentions

Protocols: Extubation, Anti-Arrhythmics and Anticoagulation

Medications the patient may have been taking pre-operatively are re-started with no change from the pre-op dosage. This includes anti-arrhythmics. Coumadin is started either the night of surgery or POD 1. Spirometry is started POD 2 or 3 via respiratory therapy. DVT prophylaxis is important.

Drains are typically removed when there is less than 250cc/day. A pre-discharge 12 lead EKG is performed, using an atrial electrogram as needed to help discern AF and atrial flutter. Specific discharge instructions are given, including typical wound precautions with emphasis upon the need to have EKGs performed at 2 weeks, 1 month and a 24-48 hour Holter at 3 months.

Cardioversion is attempted prior to discharge if warranted.

Follow-Up Protocol

We see all of our surgical patients for routine follow-up at 2 weeks post-operatively. From that point, electrophysiologists evaluate the patients at 2 or 3 months post-operatively. At 3 months, a 24 or 48 hour Holter monitor is performed. Anti-arrhythmics are discontinued if sinus rhythm is present and if the 4 month EKG reveals sinus rhythm, the Coumadin is discontinued. If any visit reveals atrial fibrillation, electro-cardioversion is considered. For completeness, 6 and 12-month EKGs are performed and 24-hour Holters as warranted by patient symptoms or complaints.

Tracking Outcomes

Following our outcomes is paramount to assess our success and to maintain an excellent referral base. A database is kept on all referred patients for the surgical treatment of AF.

Specific data included are:

- AF duration
- Previous treatment
- Success/failure to convert
- Echo data
- Concomitant heart disease
- Surgical procedure performed
- Serial EKG and Holter results
- History of stroke and peripheral vascular disease
References


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