Atrial fibrillation is the most common sustained arrhythmia in clinical practice. It affects more than 2 million people in the United States, and an estimated 150,000 new cases will be diagnosed each year. Because 4% of the US population more than 65 years old is affected, the costs to the health care system, especially Medicare, will be astronomical. Atrial fibrillation is a contributing factor in the development of angina, heart failure, and stroke. Thromboembolic events are the most feared complication of this disease. Patients with atrial fibrillation are up to 7 times more likely than the general population to have a stroke. The Centers for Disease Control and Prevention estimates that atrial fibrillation is responsible for more than 1.7 million hospitalizations of current Medicare recipients.

In this article, I describe the pathogenesis of atrial fibrillation, potential sequelae of this arrhythmia, and the treatment options. The major focus is the most current treatment modality: ablation. I also discuss nursing implications associated with this procedure.

Pathogenesis

Until the mid to late 1980s, the “multiple wavelet hypothesis,” developed by Moe, was the most widely accepted theory of the mechanism of atrial fibrillation. The arrhythmia was described as a large number of propagating wave fronts with variable refractory and conduction properties leading to the development of multiple reentrant circuits. However, to maintain atrial fibrillation, reentry requires both susceptible tissue and an initiating trigger. Haissaguerre et al brought additional insight to the pathogenesis by demonstrating that myocardial muscle fibers, known as “myocardial sleeves,” that extend from the left atrium into the pulmonary veins, are an important initiating trigger of atrial fibrillation. Specialized conduction tissue with spontaneous electrical activity and abnormal automaticity are located in the sleeves. Marked pathophysiological changes in the atrial tissue and function, known as “atrial remodeling,” modify the conduction
properties and provide the basis to sustain the arrhythmia. The resulting irregular atrial activation is the result of breakup of the wave front against tissue with variable refractory or conduction properties. The most frequent pathoanatomical changes in atrial fibrillation are atrial fibrosis and loss of atrial muscle mass, which lead to this disharmony of conduction. The presence of heart disease and/or sustained rapid atrial rates are also associated with this remodeling.

**Classification**

Atrial fibrillation is classified into 3 types (Table 1). Lone atrial fibrillation generally applies to patients younger than 60 years and occurs in the absence of cardiovascular or structural heart disease.

### Table 1 Classification system for atrial fibrillation

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paroxysmal</td>
<td>Recurs more than twice, but terminates without intervention within 7 days (usually &lt;48 h)</td>
<td>Treatment for all reversible causes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rhythm control: class I or class III antiarrhythmic agent; pulmonary vein isolation ablation after drug therapy trial unsuccessful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anticoagulation: based on risk stratification</td>
</tr>
<tr>
<td>Persistent</td>
<td>Continues longer than 7 days and/or requires intervention with pharmacological or electrical cardioversion</td>
<td>Rhythm control: electrical cardioversion; class I or class III antiarrhythmic agent; circumferential antral ablation; surgical maze procedure</td>
</tr>
<tr>
<td>Long-standing persistent</td>
<td>Continuous atrial fibrillation lasting longer than 1 year</td>
<td>Antiocoagulation: warfarin (unless contraindicated)</td>
</tr>
<tr>
<td>Permanent</td>
<td>Cardioversion unsuccessful or not attempted because a decision made not to restore normal sinus rhythm</td>
<td>Rate control: medications—digitalis, calcium channel blocker, β-blocker, amiodarone; atrioventricular node ablation/pacemaker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rhythm control: circumferential ablation and modification of affected tissue; surgical maze procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Antiocoagulation: warfarin (unless contraindicated)</td>
</tr>
</tbody>
</table>

Definitions: circumferential antral ablation, designed to surround and enclose the pulmonary veins with lines aimed at tissue outside the ostium of the pulmonary veins, termed the antrum (usually associated with additional linear lesions); pulmonary vein isolation, encircles the ostium targeting the myocardial sleeves to produce electrical isolation of the pulmonary vein from the atrium; substrate ablation, areas detected on complex fractionated atrial electrograms are targeted for ablation (these represent triggers outside the pulmonary veins).
calcium channel blockers, and amiodarone.10

**Indications and Contraindications for Ablation**

Radiofrequency ablation consists of the delivery of low-frequency, alternating current through a catheter electrode that produces thermal myocardial injury at the tip of the 4-mm catheter.2 These areas of injury, or lesions, create electrically unexcitable tissue, a situation that prevents depolarization and conduc-
tion of the electrical impulse.

Ablation to treat atrial fibrillation has progressed and is evolving as a recognized standard treatment option for some patients with this arrhythmia. According to the Heart Rhythm Society Task Force,7 catheter ablation for atrial fibrillation should generally not be considered first-line therapy. The task force concluded that the primary indication for catheter ablation is symptomatic atrial fibrillation that is refractory or intolerant to at least 1 class I or class III antiarrhythmic medication.2,7

Catheter ablation is also indicated for patients with documented heart failure and/or decreased ejection fraction who have increasing symptoms of heart failure in atrial fibrillation. Patients who do not want to take antiarrhythmic agents or have long-term anticoagulation treatment may be considered potential candidates.2 Left atrial thrombus indicated by transesophageal echocardiography and active bleeding or the inability to achieve anticoagulation are contraindications to ablation for atrial fibrillation.7 Pulmonary vein isolation ablation also should not be offered as a treatment option for any patient with atrial fibrillation who is not expected to tolerate the ablation because of advanced age, dementia, or severe heart failure.2 Structural abnormalities such as pulmonary vein stenosis should also be ruled out before ablation for atrial fibrillation is done.2

**Ablation**

To date, candidates for ablation to treat atrial fibrillation have had symptomatic, drug-refractory, paroxysmal disease.15 Most were younger than 65 years, were men, had normal ejection fractions, and generally did not have greatly enlarged atria.15,16 The duration of atrial fibrillation was 3 to 7 years, and the presence of structural heart disease was variable.15,16 Because ablation to treat atrial fibrillation is a long procedure, generally 3 to 5 hours,7,11,12 either moderate sedation or general anesthesia is used. The choice is determined by institutional practice and patient assessment.7 Duration of fluoroscopy for this procedure has been documented at more than 60 minutes.21

Current ablation techniques are focused on targeting susceptible atrial tissue, electrical triggers, or areas associated with autonomic tone.15 These factors are key to the initiation and perpetuation of the rhythm. Interrupting atrial tissue with linear lesions that block conduction was the initial concept behind the Cox maze procedure. This procedure, which requires a median sternotomy, initially involved cutting and sewing linear areas in the tissue in an attempt to interrupt all macroreentrant circuits and restore normal conduction through the atrium.17 Today, this outcome can be accomplished by an electrophysiologist as an outpatient procedure.

The most common sources of triggers are the pulmonary veins, and the cornerstone of all ablation procedures to treat atrial fibrillation is isolating the pulmonary veins from the rest of the atria through ablation lines that block conduction.18

As a trigger of atrial fibrillation, single premature depolarizations or rapid discharges from a focus in the pulmonary vein initiate atrial fibrillation and stimulate the adjacent atrium through the myocardial sleeves.19 After pulmonary vein isolation, these trigger sites are isolated from the rest of the atria by creating a continuous line of lesions that block conduction and completely enclose the sites.18

Ablation of the structurally and functionally abnormal tissue, instead of pulmonary vein isolation alone, has better results in patients with persistent or permanent atrial fibrillation and has been incorporated in an approach similar to the surgical Cox maze III procedure.12 In circumferential ablation, the pulmonary veins are isolated, then additional ablation lines are made to connect ipsilateral pulmonary veins along the left atrial roof. The left inferior pulmonary vein is connected to the mitral annulus, and an anterior line is placed between the roof and the mitral annulus.2,18 These linear lesions form barriers to conduction and therefore interrupt the reentry circuits that perpetuate atrial fibrillation.20 Multiple reentrant wavelets are required to perpetuate atrial fibrillation, and isolating areas of atrial tissue reduces the amount of...
Recent data suggest that targets for ablation are complex fractionated electrograms, that is, low-voltage, highly fractionated electrical potentials with a very short cycle length that are considered generators of atrial fibrillation. Another form of determining the affected atrial tissue involves ablation of ganglionated plexi that innervate the pulmonary veins and left atrium. Autonomic tone may also contribute to the development of atrial fibrillation. According to Pappone and Santinelli, the circumferential pulmonary vein ablation is the most effective approach because it addresses all the current theories of how atrial fibrillation is initiated, that is, isolation of triggers, modification of atrial tissue, and ablation of local vagal innervation sites.

**Ablation Procedure**

At the University of Maryland Medical Center, 90 patients had an ablation procedure between January 1, 2005, and September 9, 2008, to treat either paroxysmal or persistent atrial fibrillation after normal sinus rhythm could not be maintained by treatment with a class I or class III antiarrhythmic medication. The mean age of this group was 56 years, the mean weight was 95 kg (211 lb), and 60% were male. General anesthesia rather than moderate sedation was used for 38% of the group. However, general anesthesia became the standard in May 2007 because the length of the procedure and patients’ restlessness and back pain had led to termination in 3.3% of the previous procedures. Mean procedure time was 8.33 hours, including transesophageal echocardiography and mapping, and mean fluoroscopy time was 91 minutes.

**Care Before the Procedure**

Before a patient has an ablation for atrial fibrillation, the medical center sends the patient a teaching pamphlet explaining some important facts about the arrhythmia and the treatment. Instructions and information for before, during, and after the procedure are discussed (Table 2). Before the procedure, computed tomography is done to define the anatomy of the pulmonary veins. The imaging is normally done 3 to 5 days before the ablation so that a computer disc can be formatted and integrated with the imaging system used for mapping.

Treatment with warfarin is stopped 5 days before the ablation, and enoxaparin injections 1 mg/kg twice daily are begun 3 days before. This change is made because warfarin has a duration of 3 to 5 days, whereas enoxaparin has an elimination half-life of 4.5 hours. The treatment with enoxaparin maintains adequate anticoagulation until the ablation, while allowing normalization of clotting time at the time of femoral access. Other medication instructions are individualized for each patient.

Patients are instructed to have all laboratory tests (Table 3) done 3 to 5 days before they have computed tomography so that a creatinine level is available if injection of contrast medium is indicated. If the creatinine level is high, the amount of contrast material injected may need to be modified, and/or acetylcysteine and additional fluids must be given during and after the imaging. Preoperative preparation includes obtaining a history and physical and informed consent, reviewing the results of laboratory tests, and discussing and reviewing the teaching pamphlet to allow for further questions. In the holding area before the patient enters the electrophysiology laboratory, a 20-gauge peripheral catheter is placed for intravenous access.

**Care During the Procedure**

In the electrophysiology laboratory, the patient is oriented to the equipment and informed about what to expect during the ablation procedure. Recording patches for the mapping system, electrocardiographic and defibrillation patches, a blood pressure cuff, and a pulse oximeter are placed, a urinary catheter is inserted, and baseline readings are obtained along with a baseline assessment of sedation based on the Aldrete scale. Vital signs are obtained and sedation is assessed according to the Richmond Agitation-Sedation Scale every 5 minutes thereafter.

After intubation and induction of general anesthesia, transesophageal echocardiography is performed to rule out left atrial thrombus. A radioopaque esophageal temperature probe is inserted to allow visualization of the esophagus and monitoring of esophageal temperatures. Venous access is obtained via the right and left femoral veins. Often, the right internal jugular vein is used to place the catheter in the coronary sinus, an important reference point for mapping. This placement provides a natural curve to the coronary sinus from above and does not require a deflectable catheter.
The mapping systems used to create the anatomy of the heart show the 3-dimensional position of all diagnostic catheters relative to this stable internal reference point. Catheter location is observed via fluoroscopy, and the computerized mapping systems track the position of the catheters. A transseptal needle is advanced through the fossa ovalis or patent foramen ovale to the left atrium under continuous pressure monitoring and visualization via intracardiac ultrasound. This access allows positioning of the ablation and mapping catheter in the left atrium by the pulmonary veins. Left-sided atrial mapping is then initiated by using the CARTO XP Navigation System (Biosense- Webster, Inc, Diamond Bar, California) or the Ensite Velocity system (St Jude Medical, St Paul, Minnesota) to create 3-dimensional reconstructions of the left atrium and pulmonary veins and label the pulmonary vein ors, mitral annulus, septum, and appendage.

Once the left side of the heart has been reached, systemic heparinization is started to achieve an activated clotting time (ACT) of 300 seconds or greater. Blood samples for ACT determination are obtained every 15 minutes after administration of a 100 U/kg bolus of heparin and then every 30 minutes once the target ACT is achieved. After the target level is achieved, ablation lesions are placed circumferentially around the pulmonary veins either individually or encircling 2 ipsilateral veins at once. An ablation catheter flushed with heparinized saline at 30 mL/min

### Table 2: Instructions for patients undergoing ablation to treat atrial fibrillation

<table>
<thead>
<tr>
<th>Before the procedure</th>
<th>During the procedure</th>
<th>After the procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>You will be called by the heart center to schedule a cardiac computed tomography (CT) scan that will be used for “mapping” your left atrium (upper chamber of the heart). The scan must be done 3 to 5 days before the procedure. Blood tests must be done 3 to 5 days before the CT scan. You will need to stop taking warfarin (Coumadin) 5 days before the ablation. You may be instructed to begin injecting enoxaparin (Lovenox), a blood thinner, 3 days before the procedure. Do not inject any enoxaparin on the morning of the procedure. Have nothing to eat or drink after midnight the day of the procedure. Take all other medications with a sip of water unless instructed otherwise. Special instructions will be given if you are taking insulin or a water pill (eg, furosemide [Lasix]). You will be scheduled for a transesophageal echocardiogram (ultrasound of the heart performed from inside the tube leading from the mouth to the stomach). This imaging will be done the morning of the procedure to look for any blood clots in the left atrium. If any clots are seen, the ablation will have to be rescheduled. You will be seen by an anesthesiologist the morning of the procedure to evaluate you and to obtain your consent for general anesthesia. The procedure generally takes 4 to 8 hours to complete. A local anesthetic will be given in both the right and the left side of the groin and on the right side of the neck. Long, thin tubes called sheaths will be placed in your veins in the groin and neck, and catheters (long flexible wires) will be guided to specific locations in your heart by using fluoroscopy. A thin needle will be used to pass across the wall between the right and left atrium. The ablation is done by using radiofrequency energy applied to the tip of the catheter to create heat. The heat destroys the heart tissue around the openings of the pulmonary veins that cause atrial fibrillation. Research has shown that most atrial fibrillation signals come from the openings of the 4 pulmonary veins in the left atrium. The ablation electrically “disconnects” the pulmonary veins from the left atrium, and the abnormal signals can no longer reach the rest of the heart and trigger atrial fibrillation. Additional lesions may be required. After the ablation, the blood thinner (heparin) is allowed to wear off and the sheaths are then removed. Bed rest is required, with your legs straight, for 4 hours after sheath removal. You will usually stay in the hospital for 1 night and then be discharged the next morning. Your previous medications, including your blood thinner (warfarin) will be restarted. Because warfarin takes 3 to 5 days to reach a good level, you will be discharged with a blood thinner (enoxaparin) to be injected twice a day, along with your warfarin dose, until your international normalized ratio is greater than 2.0. Your doctor will decide how long you need to continue taking warfarin thereafter. You will continue taking warfarin for a minimum of 3 months. Prompt and continued monitoring of your international normalized ratio at the activated clotting time clinic is essential during this period to prevent stroke. Avoid vigorous activity or lifting more than 20 pounds for 1 week. You may bathe or shower the day after the ablation. It is not uncommon to have some chest discomfort, especially when taking a deep breath, for 2 to 3 weeks after the procedure because of irritation of the lining of the heart. Notify the doctor if you have any swelling or bleeding in the groin where the catheters were placed. Also notify your doctor if you are experiencing dizziness, pain or difficulty with swallowing, difficulty breathing, fever, return of atrial fibrillation, or just don’t feel right, even if it is several weeks after the procedure. Early recurrences of atrial fibrillation are common during the first 1 to 3 months, and a recurrence does not mean the procedure was unsuccessful. About 20% to 57% of patients experiencing such recurrences will not have any further occurrence during long-term follow-up.</td>
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</tbody>
</table>
### Table 3 Pathway for ablation to treat atrial fibrillation

<table>
<thead>
<tr>
<th>Step</th>
<th>Before the procedure</th>
<th>During the procedure</th>
<th>After the procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tests</strong></td>
<td>Obtain results of complete blood cell count, chemistry panel, urea nitrogen level, creatinine level, digoxin level, prothrombin time, partial thromboplastin time, international normalized ratio, and level of human chorionic gonadotropin (if patient is premenopausal) Obtain 12-lead electrocardiogram Ensure that international normalized ratio is &lt;1.5 If patient is diabetic, check blood glucose level via fingerstick Prepare for transesophageal echocardiography Obtain compact disc with computed tomography scan from radiology department for integration with mapping system</td>
<td>Measure activated clotting time (ACT) at baseline, 15 min after each heparin bolus, and then every 30 minutes once ACT goal of &gt;300 s is achieved</td>
<td>Measure ACT every hour until ACT is &lt;170 s for sheath removal Obtain electrocardiogram to detect any recurrence of atrial fibrillation If patient is diabetic, resume measuring blood glucose level via fingersticks before meals and at bedtime</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>Review history and findings on physical examination Obtain history of allergies, measure height and weight Get consent forms for general anesthesia, transesophageal esophagography, and the ablation signed and witnessed Obtain baseline vital signs, arterial oxygen saturation (Sao₂), and Aldrete score Check for history of any problems with anesthesia Begin patient identification process</td>
<td>Do final verification and time out Obtain vital signs, respiratory rate, pulse oximetry reading, and carbon dioxide level, and assess sedation every 5 min Measure fluid intake and output</td>
<td>Monitor vital signs, sedation score, and pain score to be monitored every 15 min for an hour, then every half hour for an hour, then every hour for 2 h, and every 4 h for 24 h Check insertion sites when obtaining vital signs: check for bleeding, swelling, hematoma Monitor for nausea and vomiting Monitor for signs of potential complications such as pericardial effusion, femoral bleeding or hematoma, chest pain, stroke Measure fluid intake and output</td>
</tr>
<tr>
<td><strong>Treatments</strong></td>
<td>Be sure intravenous saline lock is patent, 20-gauge needle or larger Shield gonads Apply defibrillation pads, set at 200 J Apply cautery pads per procedure Prepare setup for mapping system Assist anesthesiologist with intubation Insert urinary catheter after general anesthesia achieved Assist with transesophageal esophagography Connect arterial catheter to transducer for continuous monitoring of blood pressure and transseptal approach</td>
<td>Assist with extubation Wean patient off supplemental oxygen to keep Sao₂ &gt;94% Assist with sheath removal when ACT &lt;170 s</td>
<td>Maintain intravenous heparin lock until discharge</td>
</tr>
<tr>
<td><strong>Medications</strong></td>
<td>If patient is taking insulin or oral antihyperglycemics, ask physician if dose should be withheld or adjusted Administer other medications with sips of water unless medications are ordered withheld Be sure patient stopped taking warfarin for 5 days and was treated with heparin or enoxaparin (if outpatient) Be sure last dose of heparin was at least 4 h before the procedure</td>
<td>General anesthetic given per anesthesiologist After placement of ablation catheter in (left) side of heart, give heparin per order to maintain ACT &gt;300 s Administer intravenous fluids as ordered Administer isoproterenol infusion and observe for reinduction of atrial fibrillation as ordered</td>
<td>Administer drugs for nausea and vomiting as needed Administer pain relievers as needed Resume administration of medications used before ablation: warfarin, antiarrhythmics Administer heparin or enoxaparin 6 h after sheath removal</td>
</tr>
</tbody>
</table>
via a pump during creation of the lesions is used to prevent buildup of char, which may be associated with clot formation, at the proximal end of the ablation electrodes.\textsuperscript{2,11} This flushing can result in administration of an additional 1 to 2 L of intravenous fluid during the procedure; therefore urine output

<table>
<thead>
<tr>
<th>Step</th>
<th>Before the procedure</th>
<th>During the procedure</th>
<th>After the procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td>Instruct patient to take nothing by mouth except for medications after midnight or at least 6 h before the ablation</td>
<td>Maintain nothing by mouth</td>
<td>Have patient resume previous diet as tolerated after recovery from sedation</td>
</tr>
<tr>
<td>Activity</td>
<td>Allow activity as tolerated</td>
<td>Keep patient flat with knees elevated on pillow Immobilize patient’s extremities while patient is sedated</td>
<td>Keep patient on bed rest with head of bed &lt;30° for 4 h Keep affected extremities immobilized for 4 h after sheath removal Help patient get out of bed and ambulate the next day; do a groin check</td>
</tr>
</tbody>
</table>

| Education of patients and their families | Health problems related to admission: Explain procedure, placement of sheaths, immobility, ingestion of nothing by mouth, monitoring, and discharge care Medication/pain management: Explain that the patient will have general anesthesia during the procedure and pain management after the procedure; provide instructions for use of enoxaparin | Health problems related to admission: Explain immobilization, intubation, and monitoring Medications: Explain that the patient will have general anesthesia and control of pain during the procedure | Health problems related to admission: Review discharge instructions, ensure patient’s family is informed of procedural outcomes, restrictions, when to call physician, and follow-up appointment Medications: Review medications and their adverse effects, review pain management to be used after discharge, review instructions for enoxaparin and warfarin |

| Discharge planning | Notify patient and patient’s family of anticipated length of procedure and potential discharge time Verify that the patient has an escort or a ride home if an outpatient | Keep patient’s family informed of patient’s status during procedure and while in recovery area Report to the receiving unit: Sheath sites:________ Last ACT:______ Room assignment after recovery:______ Discharge in morning | Review that patient must do no heavy lifting or stair climbing for 24 to 48 h Review when patient may return to work Inform patient of symptoms that require notification of a physician Check for follow-up with primary cardiologist for monitoring of international normalized ratio if patient is taking warfarin Check for follow-up appointment with electrophysiologist in 1 month |

| Expected outcomes | Vital signs are stable, Sao₂ is >94% on room air, patient is afebrile Consents are signed and witnessed Results of laboratory tests are within acceptable limits Patient verbalizes understanding of education provided Patient is transported with defibrillator via stretcher/bed to electrophysiology laboratory | Insertion sites are free of bleeding or hematoma Vital signs and Sao₂ are stable, and sheaths are immobilized before patient is transferred to the recovery room Patient is experiencing no nausea or vomiting | Vital signs are stable, patient is afebrile Aldrete score is at preadmission score Patient is experiencing no nausea or vomiting Groin site is stable Patient tolerates preprocedural activity level with no dizziness Patient is given discharge instructions and prescriptions Patient and patient’s family verbalize understanding of discharge instructions and of education provided |
must be carefully monitored to assess the need for furosemide.

In electrogram-guided isolation, a second mapping catheter, called a Lasso Circular Mapping catheter (Biosense-Webster, Inc), is used. The Lasso, which is placed at the ostium of each pulmonary vein, is used to examine the circumference of the pulmonary vein antra for potentials. Radiowave energy is applied at the sites of earliest potentials until all pulmonary vein potentials are eliminated. The addition of 3-dimensional reconstructions of the left atrium and pulmonary veins obtained by using computed tomography or magnetic resonance imaging in conjunction with 3-dimensional computerized mapping and intracardiac echocardiography greatly enhance the electrophysiologist’s ability to place lesions accurately (see Figure).

At the completion of the procedure, the catheters are removed. The sheaths are left in place and are secured by using a transparent film dressing (Tegaderm Film, 3M Health Care, St Paul, Minnesota) awaiting normalization of the ACT. Staff at some medical facilities may use protamine to reverse the effects of heparin, but health care providers at Maryland Medical Center do not because of the multiple lesions in the left atrium and the associated risk of thromboembolism.

**Care After the Procedure**

After the ablation, the patient is extubated and taken to the recovery room, where blood samples for ACT determination are obtained hourly; the sheaths are removed when the target ACT of 170 seconds or less is reached. After the sheaths are removed, pressure is held at the sites for 10 minutes or until hemostasis is achieved. Adhesive bandages are applied and bed rest is maintained overnight. Vital signs, findings on neurovascular assessment, respiratory status, and cardiac rhythm are monitored after the ablation procedure. A decrease in blood pressure can occur in response to hypovolemia or to medications administered during the procedure or may indicate a pericardial effusion. Hypotension is treated with intravenous saline given as a rapid bolus, and if no response occurs within 5 minutes, emergent echocardiography is warranted. All catheter insertion sites are monitored frequently for indications of bleeding or hematoma. Bleeding is treated with direct pressure and then application of a pressure dressing. The patient is instructed to keep the legs straight for 4 hours; the head of the bed is elevated less than 30°.

Enoxaparin injections 1 mg/kg subcutaneously are started 6 hours after sheath removal to prevent clot formation and reduce risk of thromboembolism. Enoxaparin is continued twice a day for 3 to 5 days while the patient resumes taking warfarin. Of note, the international normalized ratio must be monitored during this time and the level maintained at 2.0 to 3.0 to prevent stroke.

Mild dull chest pain from inflammation caused by the ablation usually resolves during the next few days. This pain is usually alleviated by treatment with acetaminophen as needed. The swelling and inflammation caused by the ablation burns heal during the next several weeks.

**Complications**

The most dreaded complications of ablations to treat atrial fibrillation are...
are atrioesophageal fistula, pulmonary vein stenosis, cardiac tamponade, stroke, and phrenic nerve injury. In a worldwide survey, 6% of patients had major complications, including procedural death (0.05%), cardiac tamponade (1.2%), stroke or transient ischemic attack (0.9%), and pulmonary vein stenosis (1.6 %) (Table 4). Other reported complications include mitral valve trauma, acute coronary artery occlusion, air embolism, and radiation exposure.

**Success Rate**
Outcomes of ablation to treat atrial fibrillation vary depending on whether the patient has paroxysmal, persistent, or longstanding persistent atrial fibrillation (Table 5). Other variables that influence outcome are age, cardiac disease, and the size of the left atrium.

**Table 4** Complications after ablation to treat atrial fibrillation

<table>
<thead>
<tr>
<th>Complication</th>
<th>Incidence, %</th>
<th>Cause</th>
<th>Clinical manifestation</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary vein stenosis</td>
<td>1.6-38(^{15})</td>
<td>Delivery of radiofrequency energy inside the pulmonary veins(^{15})</td>
<td>Chest pain, Unexplained cough, Dyspnea, Hemoptysis,(^{12,27}) Recurrent lung infection, Pulmonary hypertension(^{1})</td>
<td>Diligent ultrasound and mapping techniques to avoid lesions in the pulmonary veins(^{12}) Angioplasty and stenting of pulmonary vein(^{12,18})</td>
</tr>
<tr>
<td>Postprocedural arrhythmias</td>
<td>5-25(^{12,28})</td>
<td>Failure to permanently isolate a pulmonary vein(^{19}) Foci outside the pulmonary veins(^{19}) Recovery of conduction from pulmonary vein to left atrium(^{2,19}) Longer duration of atrial fibrillation(^{11}) Inflammatory response to thermal injury(^{2})</td>
<td>Recurrent atrial fibrillation, Atrial tachycardia, Atrial flutter(^{2})</td>
<td>Many resolve spontaneously in 3-6 months Initial suppression with antiarrhythmic agents Repeat ablation procedure after 6 months</td>
</tr>
<tr>
<td>Vascular complications</td>
<td>0-13(^{7})</td>
<td>Number and size of venous catheters Use of arterial catheter Multiple transseptal punctures(^{25}) Anticoagulation before and after procedure(^{7})</td>
<td>Groin hematoma, Retroperitoneal bleeding, Arteriovenous fistula, Femoral pseudoaneurysm(^{23})</td>
<td>Proficiency with vascular access Avoidance of large sheaths Manual compression Surgical repair</td>
</tr>
<tr>
<td>Thromboembolism/stroke</td>
<td>0.9-7(^{12,15})</td>
<td>Thrombi on sheaths or ablation catheter(^{14}) Char formed at the catheter tip(^{11}) Disruption of atrial thrombus</td>
<td>Occurs within 24 h to 2 weeks of ablation(^{14}) Signs and symptoms depend on site of occlusion</td>
<td>Anticoagulation before and after ablation Surgical thrombectomy Warfarin and enoxaparin restarted on the day of the procedure and continued for 3 months(^{27}) Target activated clotting time to 350-400 s(^{2})</td>
</tr>
<tr>
<td>Cardiac tamponade</td>
<td>1.2-6(^{12,28})</td>
<td>Extensive catheter manipulation Need for dual transseptal punctures Need for systemic anticoagulation Multiple ablation lesions Overheating during energy delivery(^{27})</td>
<td>Chest pain, Sudden decrease in blood pressure, Reduction of the cardiac silhouette on fluoroscopy(^{27})</td>
<td>Procedure aborted Intravenous fluid replacement(^{27}) Emergent echocardiography Anticoagulation reversal with protamine(^{27}) Pericardial drainage Surgical drainage and repair(^{1})</td>
</tr>
<tr>
<td>Atrioesophageal fistula</td>
<td>&lt;0.25(^{12,30})</td>
<td>Thermal injury from posterior wall of left atrium causing damage of esophageal wall(^{1})</td>
<td>Occurs 2-4 weeks after ablation(^{12}) Fever, chills, Recurrent neurological events, Septic shock(^{1}) Death: fatal in 50% of cases(^{27}) Pericarditis, Hematemesis(^{19})</td>
<td>Insertion of esophageal temperature probe(^{1}) Use of barium paste to visualize the esophagus on radiographs Limiting power to 25 W to the posterior wall of the left atrium(^{1}) Emergent surgical intervention</td>
</tr>
</tbody>
</table>
vein isolation. This finding suggests that earlier intervention would be a better option before atrial fibrillation becomes persistent. The primary end point in most trials of ablation to treat atrial fibrillation is return of atrial fibrillation or other atrial arrhythmias, including right and left atrial flutter and atrial tachycardia. In a study in which ablation was compared with standard drug therapy, ablation showed promising results. Freedom from atrial arrhythmias at 1 year was 87% in the ablation group and only 37% in the drug group. In addition, the ablation group had a noted improvement in signs and symptoms and quality of life, an increase in ejection fraction, a reduction in the size of the left atrium, and a decrease in the number of subsequent hospitalizations.

### Discharge

Before discharge the day after the ablation, patients are instructed about medications, follow-up blood tests, and activity restrictions. They are also informed about signs or symptoms or conditions that require immediate evaluation and treatment (Tables 2 and 3).

### Follow-up

In most trials of ablation to treat atrial fibrillation, anticoagulation was discontinued after 3 to 6 months in patients who did not experience recurrent atrial fibrillation and had no incidents of thromboembolism during follow-up. The Heart Rhythm Society task force recommends that decisions about the use of warfarin beyond 2 months after ablation be based on the patient’s risk factors for stroke.

Patients should have a follow-up appointment within 3 months after the ablation and then every 6 months for at least 2 years. Basic guidelines suggest routine electrocardiography, with the addition of 24-hour Holter monitoring to document arrhythmia for any patient who has palpitations.

### Table 5

**Success rates for atrial fibrillation ablation**

<table>
<thead>
<tr>
<th>Type</th>
<th>Single procedure, %</th>
<th>Multiple procedure, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paroxysmal</td>
<td>38-78</td>
<td>54-80</td>
</tr>
<tr>
<td>Persistent</td>
<td>22-45</td>
<td>37-88</td>
</tr>
<tr>
<td>Mixed</td>
<td>16-84</td>
<td>30-81</td>
</tr>
</tbody>
</table>


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### Financial Disclosures

None reported.

### References

Ablation to Treat Atrial Fibrillation: Beyond Rhythm Control

Facts

Because ablation to treat atrial fibrillation is a long procedure, generally 3 to 5 hours, either moderate sedation or general anesthesia is used. Duration of fluoroscopy for this procedure has been documented at more than 60 minutes.

Before a patient has an ablation for atrial fibrillation, the medical center sends the patient a teaching pamphlet, explaining some important facts about the arrhythmia and the treatment. Instructions and information for before, during, and after the procedure are discussed (see Table).

Techniques for ablation to treat atrial fibrillation have advanced dramatically, but long-term follow-up is needed to evaluate benefits and assess results.

### Table

| Instructions for patients undergoing ablation to treat atrial fibrillation |
|------------------------------|------------------|------------------|
| **Before the procedure**     | **During the procedure** | **After the procedure** |
| You will be called by the heart center to schedule a cardiac computed tomography (CT) scan that will be used for “mapping” your left atrium (upper chamber of the heart). The scan must be done 3 to 5 days before the procedure. Blood tests must be done 3 to 5 days before the CT scan. You will need to stop taking warfarin (Coumadin) 5 days before the ablation. You may be instructed to begin injecting enoxaparin (Lovenox), a blood thinner, 3 days before the procedure. Do not inject any enoxaparin on the morning of the procedure. Have nothing to eat or drink after midnight the day of the procedure. Take all other medications with a sip of water unless instructed otherwise. Special instructions will be given if you are taking insulin or a water pill (eg, furosemide [Lasix]). You will be scheduled for a transesophageal echocardiogram (ultrasound of the heart performed from inside the tube leading from the mouth to the stomach). This imaging will be done the morning of the procedure to look for any blood clots in the left atrium. If any clots are seen, the ablation will have to be rescheduled. You will be seen by an anesthesiologist the morning of the procedure to evaluate you and to obtain your consent for general anesthesia. | The procedure generally takes 4 to 8 hours to complete. A local anesthetic will be given in both the right and the left side of the groin and on the right side of the neck. Long, thin tubes called sheaths will be placed in your veins in the groin and neck, and catheters (long flexible wires) will be guided to specific locations in your heart by using fluoroscopy. A thin needle will be used to pass across the wall between the right and left atrium. The ablation is done by using radiofrequency energy applied to the tip of the catheter to create heat. The heat destroys the heart tissue around the openings of the pulmonary veins that cause atrial fibrillation. Research has shown that most atrial fibrillation signals come from the openings of the 4 pulmonary veins in the left atrium. The ablation electrically “disconnects” the pulmonary veins from the left atrium, and the abnormal signals can no longer reach the rest of the heart and trigger atrial fibrillation. Additional lesions may be required. | After the ablation, the blood thinner (heparin) is allowed to wear off and the sheaths are then removed. Bed rest is required, with your legs straight, for 4 hours after sheath removal. You will usually stay in the hospital for 1 night and then be discharged the next morning. Your previous medications, including your blood thinner (warfarin) will be restarted. Because warfarin takes 3 to 5 days to reach a good level, you will be discharged with a blood thinner (enoxaparin) to be injected twice a day, along with your warfarin dose, until your international normalized ratio is greater than 2.0. Your doctor will decide how long you need to continue taking warfarin thereafter. You will continue taking warfarin for a minimum of 3 months. Prompt and continued monitoring of your international normalized ratio at the activated clotting time clinic is essential during this period to prevent stroke. Avoid vigorous activity or lifting more than 20 lb for 1 week. You may bathe or shower the day after the ablation. It is not uncommon to have some chest discomfort, especially when taking a deep breath, for 2 to 3 weeks after the procedure because of irritation of the lining of the heart. Notify the doctor if you have any swelling or bleeding in the groin where the catheters were placed. Also notify your doctor if you are experiencing dizziness, pain or difficulty with swallowing, difficulty breathing, fever, return of atrial fibrillation, or just don’t feel right, even if it is several weeks after the procedure. Early recurrences of atrial fibrillation are common during the first 1 to 3 months, and a recurrence does not mean the procedure was unsuccessful. About 20% to 57% of patients experiencing such recurrences will not have any further occurrence during long-term follow-up. |

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