ATRIAL FIBRILLATION

RESEARCH ARTICLE

Utility of Routine Pulmonary Angiography Prior to Ablation of Atrial Fibrillation: a Controlled Randomized Study

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ABSTRACT. Various imaging modalities are used during radiofrequency ablation (RFA) of atrial fibrillation (AF) with electroanatomic mapping (EM) under the assumption that this improves outcomes. However, the utility of routine imaging in AF ablation has not been well studied. Seventy-one patients undergoing irrigated tip RFA of AF were randomized to pulmonary venography or no imaging during ablation. EM was used to reconstruct the left atrium prior to ablation. Rhythm monitoring at 4–6 months was used to compare results. Baseline characteristics were similar in both groups. Contrast dose for patients undergoing venography was 44 ± 14 ml. Procedure times (294 ± 91 versus 271 ± 109 min, p = 0.33) and fluoroscopy times were not statistically longer (55 ± 16 versus 49 ± 11 min, p = 0.10) in patients undergoing venography. Creatinine prior to and post procedure was unchanged for both groups. There was one cardiac tamponade in the group without venography, and one episode of acute renal injury and an anomalous right inferior pulmonary vein (PV) in the venography group. Forty-five of 66 monitored patients (68%) were arrhythmia free on follow-up, with no difference between groups (63% versus 74%, p = 0.43). There is no significant improvement in procedural efficiency or success rates with pulmonary venography during AF ablation. This may be due to the ability of EM to define PV anatomy and the limited need for precise PV localization with circumferential ablation techniques well beyond the PV ostia.

KEYWORDS. atrial fibrillation, catheter ablation, pulmonary venography.

Introduction

Radiofrequency ablation of atrial fibrillation (AF) by isolation of the pulmonary veins (PVs) has emerged as a durable and safe therapy for symptomatic, drug-resistant AF.1–8 Initially described as ablation of focal triggers within PVs, contemporary ablative techniques sometimes include larger segments of tissue, targeting not only the PVs but also the PV antra, superior vena cava, and other non-PV trigger sites such as the coronary sinus.9,10 Non-fluoroscopic, or electroanatomic, mapping techniques have emerged as a vital part of these procedures, and have been shown to reduce procedural and fluoroscopic times as well as radiation exposure.11 Imaging modalities such as echocardiography, computed tomography (CT), magnetic resonance imaging (MRI), rotational angiography, and selective pulmonary venography continue to be used frequently, however, both to reduce the time required to perform left atrial (LA) mapping and to identify the presence of anomalous pulmonary vasculature or LA anatomy. Despite the seeming advantages, there is little systematic data to support multiple imaging modalities. In fact, in separate studies, evaluation of CT imaging showed no significant improvement in outcome over electroanatomic mapping during wide area circumferential PV isolation.12 In a
comparison of rotational angiography with electroanatomic mapping, the techniques were equivalent with respect to procedural and long-term outcomes.\textsuperscript{13} In this study, the utility of routine selective pulmonary angiography on procedural endpoints including time, radiation exposure, and safety as well as the clinical endpoint of ablation efficacy is evaluated.

**Methods**

**Patient population**

Patients with symptomatic paroxysmal, persistent, or longstanding persistent AF who had failed therapy with at least one antiarrhythmic drug and were undergoing initial AF ablation at the Medical University of South Carolina (MUSC) were eligible for inclusion. Seventy-one patients were randomized to receive AF ablation with electroanatomic mapping alone (n=36), or ablation with electroanatomic mapping and selective PV angiography (n=35). The Institutional Review Board of MUSC approved the study, and patients signed written informed consent for all procedures performed.

**AF ablation and selective pulmonary angiography**

All patients were anticoagulated for a minimum of 1 month prior to the procedure. Warfarin and all antiarrhythmic drugs (including β-blockers and nondihydropyridine calcium channel blockers) were stopped a minimum of three half-lives prior to the procedure; amiodarone was stopped 1 month prior to ablation. Warfarin was held 5 days prior to ablation, and patients were anticoagulated with low molecular weight heparin after stopping warfarin. Procedures were performed either with general anesthesia or conscious sedation, depending on physician and patient preference. All patients underwent right atrial cavotricuspid isthmus ablation prior to accessing the left atrium. Transseptal puncture was facilitated by intracardiac echocardiography (ICE); the ICE catheter was then used to monitor for the development of pericardial effusion during the procedure. Patients randomized to undergo pulmonary angiography had selective cannulation of all PVs with a 6F pigtail catheter and hand injection of 5–10 ml of intravenous contrast, opacifying the lumen of the vein. Angiograms were saved for later reference during the procedure. Electroanatomic mapping was performed in all patients using the NavX Ensite mapping system (St. Jude Medical, Minneapolis, MN). Wide area circumferential ablation of ipsilateral PVs and antra with supplemental PV isolation was carried out using a combination of electroanatomic and fluoroscopic mapping and an irrigated tip ablation catheter. Lesions surrounding the left- and right-sided veins were connected with linear ablation along the LA roof, and the inferolateral mitral isthmus was ablated (with additional lesions within the coronary sinus if needed) to achieve mitral isthmus block. Following the procedure, patients were admitted overnight for observation and reinitiation of antiarrhythmic therapy.

**Patient assessment and follow-up**

Baseline variables assessed included age, sex, left ventricular ejection fraction, number of antiarrhythmic drugs used prior to ablation, use of general anesthesia or conscious sedation intraprocedurally, and a history of congestive heart failure, coronary artery disease, diabetes mellitus, stroke, or hypertension. Procedural outcomes included fluoroscopy time, total procedure time, acute complications, and measurement of serum creatinine 24 h after ablation. Following the procedure antiarrhythmic drugs were continued for 3 months and then stopped unless AF recurred or atrial tachycardia developed. Patients who had pacemakers (PMs) or implanted cardioverter-defibrillators (ICDs) with atrial leads underwent device interrogation as a means of rhythm monitoring; other patients underwent prolonged ambulatory electrocardiographic monitoring at 3–6 months post procedure. Data extracted from long-term rhythm monitoring included the presence of AF or atrial tachycardia, total duration of the arrhythmia, and total monitoring time.

**Statistical analysis**

Univariate analysis was performed with Student’s t-test for continuous variables and Fisher’s exact test for categorical variables. It was determined that a sample of 66 patients would yield 90% confidence to detect a 10% difference between groups. All data are expressed as mean ± standard deviation. Acute renal insufficiency was prospectively defined as a 25% increase in serum creatinine following ablation.

**Results**

**Baseline characteristics**

Baseline characteristics were similar in the two groups, and are presented in Table 1. Patients were predominantly male (75%) with mean age 63±9 years; mean left ventricular ejection fraction was 60±7%. There was a low prevalence of cardiovascular or cerebrovascular disease. There was one patient in each group with hypertrophic cardiomyopathy.

**Outcomes**

Procedural outcomes were similar in the two groups (Table 2). Although not statistically different, procedure times and fluoroscopy times were longer in patients undergoing angiography. Mean contrast dose for patients undergoing angiography was 44±14 ml; six patients in the no angiography group received ≥7 ml of contrast during transseptal puncture to assist with
Visualization of the interatrial septum. Serum creatinine prior to and post procedure was unchanged for both groups. There was one cardiac tamponade in the group without venography that was treated successfully with pericardiocentesis. One episode of acute renal injury occurred in the pulmonary angiography group, with an increase in serum creatinine from 1.0 to 1.8 mg/dl at 24 h post procedure; renal function improved to baseline within 48 h of the procedure, and the patient has had no long-term sequelae. A single anomalous right inferior PV was noted in the angiography group; this finding did not significantly affect the procedural approach or outcome. Acute success rates were 100% in both groups.

Follow-up monitoring was performed in 66 patients (93%), 32 from the angiography group and 34 from the no angiography group, for an average of 535 ± 177 h. Forty-five of the 66 monitored patients (68%) were free of AF and atrial tachycardia at follow-up, with no difference between groups (Table 2).

### Discussion

Successful ablation of atrial fibrillation is often difficult, with multiple techniques and tools available. Ablative methodologies for atrial fibrillation have changed significantly since the first reports of successful ablation, and refinements continue to take place in an effort to improve procedural efficiency and outcomes. Given the complexity of AF ablation, determining the optimal approach requires critical analysis of each portion of the procedure to assess its contribution. As part of this process, multiple imaging methods have been proposed to decrease the procedure duration while maximizing successful outcomes and safety. However, rigorous evaluation of these methodologies has lagged behind their adoption.

In this study we evaluated the utility of routine pulmonary angiography to assist in defining PV anatomy and the PV ostia, and the contribution of this to overall procedural success and safety. In this series there was no significant difference in procedural efficiency, as measured by procedure and fluoroscopy time, or short-term success rates by prolonged ambulatory electrocardiographic monitoring. In our view there are two possible explanations for this finding. First, the ablative technique utilized during these procedures (wide area circumferential ablation of PVs) involves ablation well outside the PV ostia, minimizing the risk of PV stenosis and reducing the need for precise localization of the PV ostia. Second, advanced non-fluoroscopic mapping systems allow the creation of high-resolution maps to guide ablation. In experienced hands there seems to be little improvement gained by adding additional imaging to non-fluoroscopic mapping.

The consequences of these findings could be substantial. Significant resources are used prior to ablation in many centers to obtain detailed anatomic information about the left atrium. These data suggest that this approach adds no clinical benefit, and elimination of routine imaging prior to ablation has the potential to reduce cost and exposure of the patient to intravenous contrast and additional radiation.

### Limitations

There was a low incidence of anomalous pulmonary vasculature in this study compared with previous evaluations. It is possible that anomalous vessels were

### Table 1. Baseline characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Angiography (n=35)</th>
<th>No angiography (n=36)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>64 ± 10</td>
<td>62 ± 8</td>
<td>0.27</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>66</td>
<td>83</td>
<td>0.11</td>
</tr>
<tr>
<td>History of heart failure, % (n)</td>
<td>3 (1)</td>
<td>14 (5)</td>
<td>0.20</td>
</tr>
<tr>
<td>Ischemic heart disease, % (n)</td>
<td>11 (4)</td>
<td>14 (5)</td>
<td>1.0</td>
</tr>
<tr>
<td>Diabetes mellitus, % (n)</td>
<td>17 (6)</td>
<td>14 (5)</td>
<td>0.75</td>
</tr>
<tr>
<td>Hypertension, % (n)</td>
<td>64 (23)</td>
<td>63 (22)</td>
<td>1.0</td>
</tr>
<tr>
<td>Obstructive sleep apnea, % (n)</td>
<td>36 (13)</td>
<td>17 (6)</td>
<td>0.11</td>
</tr>
<tr>
<td>History of stroke or TIA, % (n)</td>
<td>9 (3)</td>
<td>19 (7)</td>
<td>0.31</td>
</tr>
<tr>
<td>Paroxysmal AF, % (n)</td>
<td>40 (14)</td>
<td>36 (13)</td>
<td>0.81</td>
</tr>
<tr>
<td>Persistent AF, % (n)</td>
<td>51 (18)</td>
<td>56 (20)</td>
<td>0.81</td>
</tr>
<tr>
<td>Longstanding persistent AF, % (n)</td>
<td>9 (3)</td>
<td>8 (3)</td>
<td>1.0</td>
</tr>
<tr>
<td>AF duration (years)</td>
<td>5.1 ± 4.8</td>
<td>4.6 ± 4.1</td>
<td>0.63</td>
</tr>
<tr>
<td>General anesthesia, % (n)</td>
<td>57 (20)</td>
<td>56 (20)</td>
<td>1.0</td>
</tr>
<tr>
<td>EF, %</td>
<td>60 ± 7</td>
<td>59 ± 8</td>
<td>0.57</td>
</tr>
<tr>
<td>Serum creatinine (mg/dl)</td>
<td>0.98 ± 0.25</td>
<td>1.06 ± 0.28</td>
<td>0.21</td>
</tr>
</tbody>
</table>

AF: atrial fibrillation; EF: ejection fraction; TIA, transient ischemic attack.

### Table 2. Procedure and follow-up outcomes

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Angiography</th>
<th>No angiography</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure time, min</td>
<td>271 ± 109</td>
<td>294 ± 91</td>
<td>0.33</td>
</tr>
<tr>
<td>Fluoroscopy time, min</td>
<td>55 ± 16</td>
<td>49 ± 11</td>
<td>0.10</td>
</tr>
<tr>
<td>AF/AT on follow-up, %</td>
<td>28</td>
<td>35</td>
<td>0.43</td>
</tr>
</tbody>
</table>

AF: atrial fibrillation; AT.
poorly detected by pulmonary angiography in this study, but we suspect the difference lies more in the definition of anomalous vasculature between evaluations, and PV findings with CT and pulmonary angiography have been similar in side-to-side comparisons. It is possible that selective pulmonary venography may have been unable to detect smaller veins of insufficient size to allow entry of the pigtail catheter. Subsequent mapping with the ablation catheter in patients who had previously undergone pulmonary angiography did not identify veins that were not already noted with venography, suggesting either the lack of accessory veins in this group or that catheter mapping is no more sensitive at detecting smaller veins than venography. Determination of the utility of pulmonary angiography in this study was determined with wide area circumferential ablation; it is possible that different techniques involving ablation closer to the PV ostia would yield different results.

Conclusion

There is no significant improvement in procedural efficiency or success rates with pulmonary venography during AF ablation. This may be due to the ability of non-fluoroscopic (electroanatomic) mapping to define PV anatomy and the limited need for precise PV localization with circumferential ablative techniques well beyond the PV ostia.

References