Low complication rates using high power (45–50 W) for short duration for atrial fibrillation ablations

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BACKGROUND Many centers use radiofrequency (RF) energy at 25–35 W for 30–60 seconds. There is a safety concern about using higher power, especially on the posterior wall.

OBJECTIVE The purpose of this study was to examine complication rates for atrial fibrillation (AF) ablations performed with high-power, short-duration RF energy.

METHODS We examined the complication rates of 4 experienced centers performing AF ablations at RF powers from 45–50 W for 2–15 seconds per lesion. In total, 13,974 ablations were performed in 10,284 patients. On the posterior wall, 11,436 ablations used power 45–50 W for 2–10 seconds, and 2538 ablations used power reduced to 35 W for 20 seconds. Esophageal temperature monitoring was used in 13,858 (99.2%).

RESULTS Demographics were age 64 ± 11 years, male 68%, left atrial size 4.4 ± 0.7 cm, paroxysmal AF 37%, persistent AF 42%, longstanding AF 20%, antiarrhythmic drugs failed 1.4 ± 0.7, hypertension 54%, diabetes 15%, previous cerebrovascular accident/transient ischemic attack 7%, and CHA2DS2-VASc score 2.1 ± 1.4. Procedural time was 116 ± 41 minutes. Complications were death in 2 (0.014%; 1 due to stroke and 1 due to atrioesophageal fistula), pericardial tamponade in 33 (0.24%; 26 tapped, 7 surgical), strokes <48 hours in 6 (0.043%), strokes 48 hours–30 days in 6 (0.043%), pulmonary vein stenosis requiring intervention in 2 (0.014%), phrenic nerve paralysis in 2 (0.014%; both resolved), steam pops 2 (0.014%) without complications, and catheter char 0 (0.00%). There was 1 atrioesophageal fistula in 11,436 ablations using power 45–50 W on the posterior wall and 3 in 2538 ablated with 35 W on the posterior wall (P = .021), although 2 of the 3 had no esophageal monitoring during a fluorosceous procedure.

CONCLUSION AF ablations can be performed at 45–50 W for short durations with very low complication rates. High-power, short-duration ablations have the potential to shorten procedural and total RF times and create more localized and durable lesions.

KEYWORDS Ablation complications; Atrial fibrillation; Atrioesophageal fistula; High-power; Short-duration radiofrequency ablation

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Introduction

Radiofrequency (RF) ablation is widely accepted as a treatment for patients with atrial fibrillation (AF). Successful ablation outcomes require durable lesion formation, either to isolate the pulmonary veins (PVs) or to perform other needed ablations such as those for atrial flutter or tachycardia. Creating a durable RF lesion depends on the RF current delivered, the duration of RF energy delivery, the degree of catheter tissue contact, and catheter stability.1 Previous studies evaluated increased power (ie, current) to 45–50 W for AF ablation.2–5 One study using higher power without reducing RF lesion duration showed improved ablation outcomes but also an increase in complications.2 Another
study using 50-W lesions for shorter durations reported increased ablation outcome efficacy without an increase in complications.\textsuperscript{1} The use of higher power for ablation consistently results in shorter procedural times, reduced fluoroscopy dose, and decreased total RF energy delivery.\textsuperscript{2–4} Many centers currently performing RF ablation use power of 25–35 W for durations of 30–60 seconds at each site.\textsuperscript{6,7} There is concern about the safety of using higher-power RF energy for AF ablation, especially on the posterior wall. Recent animal studies suggest that 50-W ablations for 5 seconds are superior to lower-power, longer-duration ablations for creating lesions and had lower complication rates.\textsuperscript{8,9} In a small study in humans using contact force-sensing catheters, use of 50 W for an average of 11 seconds at each site resulted in excellent clinical outcomes with no complications.\textsuperscript{10} Because all of the published studies using higher power for short durations have been single-center studies with relatively small numbers of patients, we examined a multicenter experience using higher powers for short durations for safety, with special emphasis on posterior wall ablation.

Methods
Patient population
The subjects were consecutive patients undergoing AF ablation for standard clinical indications at 4 experienced ablation centers. The study was approved by the Western Institutional Review Board. All patients provided written informed consent for the ablation procedure. The patient data were prospectively collected in the AF database, which is approved by the Western Institutional Review Board.

Ablation procedure
Ablations were performed from September 2006 through November 2017 using standard commercially available, open irrigated-tip catheters, and 3-dimensional mapping systems. All centers used irrigated-tip RF at power of 45–50 W for short durations of 5–15 seconds in the left atrium other than on the posterior wall. On the posterior wall, some operators used 45–50 W for 2–10 seconds, and others reduced RF power to 35 W and increased the duration of energy delivery to 20 seconds. For each ablation procedure, we determined whether the patient had esophageal temperature monitoring. The position of the thermistor was adjusted during the procedure as needed. With such short-duration ablations, a temperature rise occurred frequently on the thermistor catheter only after RF energy delivery had been completed. If the temperature rise was observed during RF energy delivery, RF energy was interrupted as soon as a temperature rise was noted or when the temperature reached 39°C. When a temperature rise occurred, no further ablation was delivered at that site until the temperature returned to baseline. Termination of RF energy delivery was guided by loss of local electrograms as the primary endpoint throughout the duration of our study. In later years, RF energy delivery was also guided by loss of pacing capture on the ablation electrode during RF energy delivery was also guided by loss of local electrograms as the primary endpoint throughout the duration of our study. In later years, RF energy delivery was also guided by loss of pacing capture on the ablation electrode during RF energy delivery was also guided by loss of pacing capture on the ablation electrode during.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographics of the study population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>64 ± 11</td>
</tr>
<tr>
<td>Female gender</td>
<td>3320 (32)</td>
</tr>
<tr>
<td>Left atrial size (cm)</td>
<td>4.4 ± 0.7</td>
</tr>
<tr>
<td>Duration of AF (y)</td>
<td>5.7 ± 7.8</td>
</tr>
<tr>
<td>Body mass index</td>
<td>30 ± 6</td>
</tr>
<tr>
<td>Paroxysmal AF</td>
<td>3827 (37.2)</td>
</tr>
<tr>
<td>Persistent AF</td>
<td>4365 (42.6)</td>
</tr>
<tr>
<td>Longstanding AF</td>
<td>2092 (20.3)</td>
</tr>
<tr>
<td>No. of arrhythmics drugs failed</td>
<td>1.4 ± 0.7</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>2051 (19.9)</td>
</tr>
<tr>
<td>Obstructive sleep apnea</td>
<td>1634 (15.9)</td>
</tr>
<tr>
<td>Dilated cardiomyopathy</td>
<td>1056 (10.3)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>5654 (53.9)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1514 (14.7)</td>
</tr>
<tr>
<td>Prior stroke or transient ischemic attack</td>
<td>716 (7.0)</td>
</tr>
<tr>
<td>CHA2DS2-VASc score</td>
<td>2.1 ± 1.4</td>
</tr>
<tr>
<td>CHADS2 score</td>
<td>1.3 ± 1.0</td>
</tr>
</tbody>
</table>

Values are given as mean ± SD or n (%), unless otherwise indicated. AF = atrial fibrillation.

RF energy delivery, achievement of a 10% impedance drop during RF energy delivery, or achievement of the target lesion size index (LSI) value. PV isolation was the primary goal of all ablations, and additional ablations were undertaken as clinically indicated. Anticoagulation was handled individually at each center according to their customary routines.

Data analysis
For each patient, we determined age, gender, left atrial size, type of AF (paroxysmal = AF episodes <1 week; persistent = AF episodes 1 week–1 year; or longstanding = AF episodes >1 year), number of antiarrhythmic drugs failed, CHA2DS2-VASc score, and presence or absence of hypertension, diabetes, and previous stroke or transient ischemic attack. For each ablation, we determined procedural, fluoroscopy, and total RF times. Complications were reported on a per procedure basis. Complications examined were death, incidence of pericardial tamponade, strokes occurring within 48 hours and strokes occurring from 48 hours–30 days, PV stenosis requiring intervention, phrenic nerve paralysis, atrioesophageal fistulas, steam pops, and catheter char. For atrioesophageal fistulas, we evaluated the patients by subgroup according to whether the full 45–50 W of power was used on the posterior wall for short durations or the power on the posterior wall was reduced to 35 W for 20 seconds.

Statistical analysis
Statistical analysis was performed using XL Stat 2017(XL Stat, Paris, France). Continuous data are given as mean ± SD and count and percent if categorical. The Fisher Exact test was used for the difference in atrioesophageal complication rates between the group having high power vs reduced power on the posterior wall. All statistical tests were 2-sided, and $P < .05$ was considered significant.
Strokes 48 hours

Atrioesophageal

PV stenosis requiring intervention

Phrenic nerve paralysis

Left atrial steam pops

Catheter char

Atrioesophageal fistula high-power posterior wall

Atrioesophageal fistula lower-power posterior wall

Table 2  Per procedure complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Total no.</th>
<th>Percent of ablations</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pericardial tamponade</td>
<td>33</td>
<td>0.24</td>
<td>26 tapped, 7 surgery</td>
</tr>
<tr>
<td>Strokes in first 48 hours</td>
<td>6</td>
<td>0.043</td>
<td>1 death, 1 with residual</td>
</tr>
<tr>
<td>Strokes 48 hours to 30 days</td>
<td>6</td>
<td>0.043</td>
<td>None with residuals</td>
</tr>
<tr>
<td>PV stenosis requiring intervention</td>
<td>2</td>
<td>0.014</td>
<td>Both treated successfully</td>
</tr>
<tr>
<td>Phrenic nerve paralysis</td>
<td>2</td>
<td>0.014</td>
<td>Both recovered</td>
</tr>
<tr>
<td>Left atrial steam pops</td>
<td>2</td>
<td>0.014</td>
<td>No consequences</td>
</tr>
<tr>
<td>Catheter char</td>
<td>0</td>
<td>0.00</td>
<td>Survivor with surgery</td>
</tr>
<tr>
<td>Atrioesophageal fistula high-power posterior wall</td>
<td>1</td>
<td>0.0087</td>
<td>Survived with surgery</td>
</tr>
<tr>
<td>Atrioesophageal fistula lower-power posterior wall</td>
<td>3</td>
<td>0.12</td>
<td>1 death, 2 survived with surgery</td>
</tr>
</tbody>
</table>

PV = pulmonary vein.

Results

Patient population

Patient demographics are summarized in Table 1. A total of 13,974 ablations were performed in 10,284 patients (average patient age 64 ± 11 years, male gender 68%, average left atrial size 4.4 ± 0.7 cm). AF was paroxysmal in 37%, persistent in 42%, and longstanding in 20%. The patients had an average CHA2DS2-VASc score of 2.1 ± 1.4.

Procedural data

All ablations were performed using irrigated-tip RF at power of 45–50 W in the left atrium for 5–15 seconds at each site. On the posterior wall, 11,436 ablations used 45–50 W for 2–10 seconds, and 2538 ablations had power reduced to 35 W applied for 20 seconds. Esophageal temperature monitoring was used in 13,858 (99.2%). The initial ablation procedural time was 116 ± 41 minutes. Average fluoroscopy time was 33 ± 6 minutes, and average RF time was 39 ± 30 minutes.

Complications

Complications are summarized in Table 2. Pericardial tamponade occurred in 33 ablations (0.24%); 26 patients underwent pericardiocentesis and 7 required surgical intervention. For most patients, determining whether the pericardial tamponade was related to catheter manipulation, transeptal puncture, or RF energy delivery was difficult. One of the patients undergoing pericardiocentesis developed pericardial tamponade before delivery of any RF energy. Among the 7 patients treated surgically, 3 perforations did not seem to be related to left atrial RF energy delivery (1 coronary artery tear, 1 coronary sinus tear from a diagnostic catheter, and 1 right atrial perforation). The site of bleeding was not determined in 2 patients who had achieved hemostasis by the time the chest was opened, and 2 patients had left atrial perforations that could have been due to RF energy delivery. Six strokes (0.043%) occurred in the first 48 hours, and 6 strokes (0.043%) occurred from 48 hours–30 days. One patient with a stroke died, and only 1 other stroke left any residual deficit. PV stenosis requiring intervention occurred in 2 patients (0.014%), and phrenic nerve paralysis occurred in 2 patients (0.014%). Both cases of phrenic nerve paralysis resolved spontaneously over time. Left atrial steam pops were heard without complications in 2 ablations (0.014%), and catheter char was not observed in any ablations. One atrioesophageal fistula occurred in 11,436 ablations (0.0087%) performed using 45–50 W power for short durations on the posterior wall, and 3 occurred in the 2538 patients (0.12%) ablated with 35 W on the posterior wall for longer durations ($P = .021$). Two of the 3 atrioesophageal fistulas occurring in the 35-W group were in a small subset of 58 patients who did not undergo esophageal temperature monitoring during a fluororless procedure. Two deaths (0.014%) resulted from the procedures, 1 due to a stroke and 1 after an atrioesophageal fistula. The other patients with atrioesophageal fistulas survived without sequelae after surgical repair.

Discussion

The main finding of this study is that RF ablation can be performed safely in the left atrium (including the posterior wall) using 45–50 W with short durations of 5–15 seconds at each site in the LA and 2–10 seconds on the posterior wall.

Despite clinical apprehension about the use of higher power, especially on the posterior wall, several animal studies support the use of 50-W ablations for 5–10 seconds. Higher-power, shorter-duration RF delivery is thought to destroy tissue, mostly through local resistive heating, which occurs early during an RF application. It avoids the distant conductive heating tissue damage that predominates later during long RF applications. In freshly killed porcine ventricles, Goyal et al showed that the time to create a 4-mm-deep lesion was >20 seconds for 20-W ablations and only 6–7 seconds for 50-W ablations. They suggested that these high-power, short-duration RF applications might help reduce collateral injury. Bhaskaran et al8 examined 50- and 60-W ablations for 5 seconds vs conventional 40-W ablations for 30 seconds delivered at a contact force of 10g in an in vitro and in vivo sheep model. They showed that 50- and 60-W ablations for 5 seconds achieved transmural lesions and were safer than 40-W ablations for 30 seconds. The incidence of steam pops was 8% in the 40-W/30-second ablations vs none in the 50- and 60-W ablations for 5 seconds. They did suggest an upper limit to power, with an 80-W ablation for 5 seconds causing an 8% occurrence of steam pops. Another study examined 90-W/4-second ablations using a sophisticated automated temperature sensing and feedback mechanism to safely create lesions.11 They compared 90-W ablation for 4 seconds to 25 W for 20 seconds. The 90-W/4-second ablations all had full-
thickness lesions with no gaps, whereas the 25-W/20-second lesions resulted in some partial-thickness lesions and many gaps between lesions. At 25 W for 20 seconds, irrigation of the catheter tip seemed to cause “endocardial sparing,” thought to be a failure to create scar because of cooling of the endocardium by irrigation before resistive heating could destroy the tissue.

Previous studies have evaluated higher-power, short-duration ablations in humans. None of the studies were large enough to examine the occurrence of rare complications such as atrioesophageal fistulas or PV stenosis. Nilsson et al1 compared ablations using 30 W for 120 seconds to 45 W for 20 seconds. Long-term outcome and complications were identical in the 2 groups. The group receiving the higher-power, short-duration ablation had a reduction in PV isolation time, mean fluoroscopy time, radiation dose, and total RF application time. Another study compared an open irrigated-tip catheter using either 35 or 50 W.2 For the patients undergoing ablation at 50 W, there was an 82% freedom from AF compared to 66% freedom from AF for patients only receiving 35 W and the 50 W group and they had reduced fluoroscopy and left atrial times. That study did not shorten the duration of the 50-W ablations, and steam pops, pericardial effusions, and gastrointestinal complaints were noted. The investigators speculated that shortening the duration of RF energy delivery might have reduced the complication rate. Bunch and Day5 reported on the use of 50 W for short durations using a “painting” technique of moving the catheter across a small area until it was devoid of electrograms. They noted no esophageal injuries and an 85% freedom from AF after 1 or 2 ablations with follow-up of 338 days. Winkle et al1 compared the use of open irrigated-tip catheters at 50 W for short durations of 3–10 seconds at each site to lower power applied for 25–40 seconds at each site. The short-duration, 50-W ablations had better long-term freedom from AF and shorter procedural, left atrial, and fluoroscopy times without an increase in complications. A recent study using point-by-point ablation and contact force-sensing catheters had a 2-year freedom from AF after a single procedure of 86% for paroxysmal AF and 72% for persistent AF.10 The average 50-W energy delivery time was only 11.2 ± 3.7 seconds at each site. The total RF energy delivered was only 895 ± 258 seconds per procedure.

Several parameters can be followed when using high-power, short-duration ablation to indicate that a lesion has formed and that no further ablation is needed. This will help avoid ablating for durations longer than needed to destroy tissue. These parameters include monitoring loss of pacing capture during RF delivery,10 observing a drop in the impedance,12 and following some metric of lesion formation such as the Lesion Size Index10 or the Ablation Index.13

Our retrospective analysis cannot provide definitive information on whether high-power, short-duration lesions are safer than low-power energy delivered for longer periods of time. Nonetheless, the extremely low complication rate, including a very low incidence of atrioesophageal fistulas, should be reassuring that using 45–50 W for short durations in the left atrium, including the posterior wall, is not associated with an inordinate number of serious complications. The extremely low complication rate we report in this study should encourage physicians to consider the use of short-duration, higher-power RF ablations to take advantage of the reduction in procedural, fluoroscopy, and total RF energy delivery times. Although we did note fewer atrioesophageal fistulas in the group with high-energy, short-duration lesions on the posterior wall compared to the lower-energy, longer-duration lesions, the data are clouded by the fact that 2 of the 3 atrioesophageal fistulas in the group in which power was reduced on the posterior wall occurred in a small subset of patients without esophageal temperature monitoring undergoing a fluoroscopy procedure. When ablating on the posterior wall at any power, attention should be paid to the location of the esophagus. All operators in our study shortened RF delivery by a few seconds when ablating with high power near the esophagus. Furthermore, when temperature rises did occur, no further ablations were given in that area until the temperature returned to baseline to avoid any adverse effects of “temperature stacking.”

Atrioesophageal fistulas are an extremely rare complication of ablation, and obtaining a precise number for a true incidence of atrioesophageal fistulas is difficult. Our data suggest that this complication is highly infrequent with careful high-power, short-duration ablation on the posterior wall using esophageal monitoring.

Study limitations
This study was a retrospective study. It covered a span >10 years, and changes in ablation catheters and mapping systems occurred over that time. Although we examined only a change in RF power setting up to 45–50 W, many other factors such as contact force or catheter stiffness could have contributed to both complications and efficacy. We cannot give a specific time to ablate because many of our lesions were ablated using a drag and or painting technique, and the times of 2–15 seconds at each site are only estimates. We did not routinely perform postablation computed tomographic scans to look for asymptomatic PV stenosis. We did not attempt to look at long-term freedom from AF in our patients. Without such efficacy data, it is difficult to put into perspective the value of high-power, short-duration ablations. Our excellent safety profile using this technique should allow future studies to further examine both safety and efficacy compared to lower-power, longer-duration RF energy delivery.

Conclusion
AF ablations can be performed at 45–50 W for short durations with very low complication rates. High-power, short-duration ablations have the potential to shorten procedural and total RF times and create more localized and durable lesions.
Acknowledgments
Patricia Barberini, RN, Cynthia Lebsack, PharmD, and Glenda Rhodes assisted with data and manuscript management.

Appendix
Supplementary data
Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrthm.2018.11.031.

References