Background—Transseptal puncture with a conventional mechanical technique can fail because of a resistant interatrial septum. We evaluated the efficacy and safety of a new method to cross-resistant septae by transmitting radiofrequency (RF) energy through the transseptal needle.

Methods and Results—Among 269 consecutive transseptal punctures, 13 (5%) were unsuccessful in 12 different patients (11 men aged 52+12 years) using the conventional Brockenbrough technique. All 12 patients had previously undergone at least 1 transseptal catheterization. The needle position in relation to the fossa ovalis was assessed by fluoroscopy in orthogonal views and was confirmed with contrast injection and by visualizing the characteristic “tenting” of the fossa ovalis. Before using RF energy, there were a median of 6 unsuccessful attempts to perforate the septum conventionally, with 1 pericardial puncture (with a nonsignificant effusion). RF transseptal puncture was then performed by delivering unipolar RF with manual contact between the ablation catheter and the proximal extremity of the needle at the patient’s groin. RF transseptal puncture was achieved at the first attempt in all patients within a median of 1 second (interquartile range, 1 to 4) and without any complication. The only parameter predictive of a septum resistant to conventional puncture was the total number of transseptal catheterizations (3.2±1 versus 1.8±1, P<0.001).

Conclusion—Transmission of RF energy from the ablation catheter up to the tip of the transseptal needle provides an easy and safe method for piercing the fossa ovalis when the conventional approach fails because of a resistant septum. (Circ Arrhythmia Electrophysiol. 2008;1:169-174.)

Key Words: transseptal puncture ▪ left atrium access ▪ radiofrequency ▪ atrial fibrillation ▪ resistant septum
Electrophysiological Study
Antiarhythmic drugs, with the exception of amiodarone, were withdrawn for at least 5 half-lives before the procedure. Oral anticoagulation (target INR, 2–3) was maintained for at least 1 month before the procedure, and all patients underwent transesophageal echocardiography (TEE) within 48 hours of the procedure to exclude the presence of atrial thrombus.

Electrophysiological studies were performed in the fasting state using conscious sedation. The following catheters were introduced via the right femoral vein: (i) a steerable quadri- or decapolar catheter (5-mm electrode spacing, Xtrum, ELA Medical, Le-Plessis-Robinson, France) was positioned within the coronary sinus; (ii) a decapolar circumferential mapping catheter (Lasso, Biosense Webster, Diamond Bar, Calif.) was introduced into the LA and stabilized using a long sheath (SL 0, Saint-Jude Medical, Minn.) continuously perfused with heparinized saline; and (iii) a 3.5-mm externally perfused with heparinized saline; and (iii) a 3.5-mm externally irrigated-tip ablation catheter (Thermocool, Biosense Webster, Diamond Bar, Calif.) was introduced into the LA and stabilized using a long plastic sheath isolating the body of the needle from other anatomic structures.

Energy was transmitted from the ablation catheter to the needle by simple contact. Energy was concentrated at the tip of the needle, with watts transmitted from the ablation catheter to the needle by contact injection. Particular attention was paid to avoid any contact between the needle and the patient’s skin. Unipolar RF energy of 30 watts was then transmitted from the ablation catheter to the needle by single contact. Energy was concentrated at the tip of the needle, with the long plastic sheath isolating the body of the needle from other anatomic structures.

Conventional Transseptal Catheterization
The presence of a patent foramen ovale was excluded by prior TEE approach as follows.

A catheter was inserted in the coronary sinus while the ablation catheter was placed at the His position. Intracardiac echocardiography or aortic root visualization were not routinely used. A long sheath and dilator were advanced into the superior vena cava over a 0.035" guide wire inserted via the femoral vein. The guide wire was removed and a Brockenbrough needle (St. Jude Medical, Minneapolis, Minn.) was inserted until it was 5 mm from the extremity of the dilator. Pressure was monitored by a pressure transducer connected to the needle. Using an antero-posterior fluoroscopic projection, the transseptal apparatus was oriented toward the interatrial septum (4 to 5 o’clock position) and was rapidly withdrawn until a jump was visualized, indicating the location of the fossa ovalis. The apparatus was then advanced slightly to ensure good contact with the fossa ovalis. The position of the needle was confirmed using different fluoroscopic projections (from right anterior oblique to left lateral) and contrast injection. The needle was oriented posterior to the His position and parallel to the proximal coronary sinus. The needle was then quickly advanced across the septum. LA access was confirmed by contrast injection. After stabilizing the transseptal apparatus a few millimeters inside the LA, the needle was removed and the guide wire was advanced toward the left superior pulmonary vein. The sheath and dilator were then withdrawn to the right atrium and the ablation catheter was introduced via the same hole. The sheath was then repositioned in the LA and the dilator and guide wire were slowly removed.

Transseptal Catheterization With Resistant Septum
In all cases where puncture of the interatrial septum failed with the conventional technique, the novel RF technique was attempted. The needle position was assessed again in relation to the CS catheter and the His and importantly, visualization of the tenting of the fossa ovalis with needle advancement with simultaneous contrast injection (Figure 1). Multiple forceful attempts to pierce the septum were attempted. If this failed, the standard irrigated-tip ablation catheter used for ablation (Thermocool, Biosense Webster, Diamond Bar, Calif.) was brought into contact with the proximal extremity of the needle, the tip of which being still in contact with the fossa ovalis (Figure 2). Particular attention was paid to avoid any contact between the needle and the patient’s skin. Unipolar RF energy of 30 watts was then transmitted from the ablation catheter to the needle by simple contact. Energy was concentrated at the tip of the needle, with the long plastic sheath isolating the body of the needle from other anatomic structures.

Statistical Analysis
Continuous variables are expressed as mean ± SD except for count and time variables that are expressed as median and interquartile (IQ).
range. Statistical significance was assessed using the unpaired Student *t* test or Mann-Whitney test if necessary. Categorical variables, expressed as numbers or percentages, were analyzed with the *χ²* test or Fisher exact test. All tests were 2-tailed, and a probability value <0.05 was considered statistically significant.

**Results**

**Patients’ Characteristics**

There were 12 patients (11 men), aged 52±12 years (range, 28 to 64) with a median AF history of 90 months (IQ range, 48 to 120). Four patients had paroxysmal AF and 8 patients had persistent AF. All patients had undergone at least 1 previous transseptal catheterization (range, 1 to 5). The indications for redo procedures were left-sided atrial tachycardia in 11 patients and AF in 1 patient. Two patients (17%) had cardiac disease: 1 patient had hypertrophic cardiomyopathy and 1 patient had valvular heart disease, with aortic and mitral mechanical valves (see Table 1 for details).

Left ventricular diastolic diameter was 53±3 mm (range, 46 to 58) with an ejection fraction of 57±19% (20 to 78) and LA diameter of 49±8 mm (range, 37 to 60). TEE performed before the procedure did not reveal any abnormalities in the interatrial septum in the form of aneurysm or an abnormally thick septum (i.e., ≥2 mm).

Characteristics of the patients requiring RF transseptal access were compared with the control group of 269 patients with conventional transseptal puncture (Table 2). The only parameter associated with resistant septum was the total number of transseptal catheterizations (3.2±1 versus 1.8±1, *P*<0.001).

**Transseptal Catheterization**

Orthogonal fluoroscopic views (antero-posterior and left lateral) as well as contrast injection were used in all the patients to confirm correct positioning of the needle against the fossa ovalis (Figures 1 and 3). There were a median of 6 attempts (IQ range, 5 to 7) to perforate the septum using the conventional Brockenborough method, before using RF energy. A pericardial effusion of <0.5 cm was observed in 1 patient (without requiring pericardiocentesis), because of posterior right atrial puncture. The duration of the manipulation of the transseptal apparatus for puncture attempts was 11 minutes (IQ range, 10 to 16) before using RF energy.

Unipolar RF was then delivered by simple manual contact between the standard ablation catheter and the proximal end of the needle (Figure 2). Septal puncture was achieved at the first attempt in all 12 patients within a median of 1 second of RF delivery (IQ range, 1 to 4) and without any complications. During RF delivery, impedance at the catheter tip was 156 Ohms (IQ range, 139 to 194), temperature was 31°C (IQ range, 30 to 32), and RF power was 19 watts (IQ range, 15 to 20) (Table 1). The sheath and the ablation catheter were easily advanced into the LA for all patients using the same transseptal hole.

One patient underwent a redo procedure 3 months after transseptal puncture using RF delivery. Interestingly, the transseptal puncture was closed, as demonstrated by TEE and catheter probing. Furthermore, the interatrial septum was again resistant to standard mechanical puncture, and a second use of RF delivery was required. This method allowed again for almost instantaneous access to the LA.

**Discussion**

This study describes a simple, rapid, and effective method to cross a resistant interatrial septum allowing access to the LA chamber. This was performed safely and without any additional equipment.

**Resistant Transseptal Puncture**

AF is treatable by catheter ablation for most patients.16-19 However, more than 1 procedure is required in many cases, particularly in patients with persistent AF.6,16 Redo procedures are mainly performed for atrial tachycardia,7 that is
often more symptomatic than AF. Marcus et al have already demonstrated that repeat transseptal catheterization may be more difficult and even “impossible” in some cases. They have hypothesized that this could be because of possible fibrosis or increased interatrial thickness due to the proinflammatory effect of the initial transseptal catheterization. Interestingly, our study demonstrated that the only parameter associated with resistant septum was the total number of transseptal catheterizations. All of the patients had had at least one previous transseptal puncture. Conversely, none of the echocardiographic data could predict the presence of a resistant septum. In particular, the septal thickness was always <2 mm, which is considered as a normal measurement. This is in favor of fibrosis following prior transseptal access instead of a thickened septum.

Use of RF for Transseptal Puncture
RF energy generates intracellular warming and requires at least 100°C locally to perforate the atrial tissue. RF energy does not stimulate nerve or muscle cells because of its high frequency, avoiding pain or arrhythmias. Early studies describing RF use to perforate the interatrial septum have been carried out in the context of congenital heart disease. In these early studies, the aim was to create an iatrogenic transseptal defect to improve cardiac hemodynamic; however, this required specialized equipment that was limited to this task only. This specific tool has also been used in the context of percutaneous balloon mitral valvuloplasty. In this aforementioned study, Sakata et al evaluated RF delivery in 4 patients using dedicated apparatus that required a 14-F sheath and intracardiac ultrasound to confirm the accurate localization of the perforation site and to monitor the transseptal advance of the catheter system. RF delivery to pierce the septum was effective in all cases within only 2 seconds and 5 watts of delivery. More recently, Bidart et al described RF delivery using electrocautery assistance as used in surgery. Using the “cutting” setting, electrocautery was effective as the septum could also be crossed immediately in all patients. However, it is of note that electrocautery assistance is not available in many electrophysiological laboratories.

In our study, the median RF time delivery needed to pierce the fossa was 1 second. For all cases except one, the perforation of the interatrial septum was almost instantaneous using RF delivery (before the power had even reached 10 watts), whereas it was “impossible” by conventional approach. In a single case, it took longer (11 seconds) presum-

Table 2. Comparison Between Patients With or Without Resistant Transseptal Puncture

<table>
<thead>
<tr>
<th></th>
<th>Resistant Septum (n=12)</th>
<th>Control Group (n=269)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>52 ± 12</td>
<td>56 ± 12</td>
<td>NS</td>
</tr>
<tr>
<td>Men</td>
<td>92%</td>
<td>85%</td>
<td>NS</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>88 ± 13</td>
<td>83 ± 14</td>
<td>NS</td>
</tr>
<tr>
<td>AF history, median mo</td>
<td>90</td>
<td>90</td>
<td>NS</td>
</tr>
<tr>
<td>No. of transseptal punctures</td>
<td>3.2 ± 1</td>
<td>1.8 ± 1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Heart disease</td>
<td>17%</td>
<td>23%</td>
<td>NS</td>
</tr>
<tr>
<td>External cardioversions</td>
<td>2 ± 3</td>
<td>3 ± 3</td>
<td>NS</td>
</tr>
<tr>
<td>Antiarrhythmic drugs</td>
<td>2 ± 1</td>
<td>2 ± 2</td>
<td>NS</td>
</tr>
<tr>
<td>Left end-diastolic diameter, mm</td>
<td>53 ± 3</td>
<td>54 ± 9</td>
<td>NS</td>
</tr>
<tr>
<td>Left ventricular ejection fraction, %</td>
<td>57 ± 19</td>
<td>58 ± 14</td>
<td>NS</td>
</tr>
<tr>
<td>Left atrial diameter, mm</td>
<td>49 ± 8</td>
<td>45 ± 9</td>
<td>NS</td>
</tr>
</tbody>
</table>

AF indicates atrial fibrillation.

Figure 3. Anteroposterior fluoroscopic view of the chest. Decapolar catheter placed inside the coronary sinus. Despite the good positioning of the needle at the fossa ovalis, this structure was resistant to puncture even though multiple attempts were made. After confirming the correct positioning of the tip of the needle in relation to the interatrial septum with orthogonal fluoroscopic views and contrast injection (panel A), radiofrequency energy transmitted from the ablation catheter to the proximal extremity of the needle at the patient’s groin resulted in left atrial access within 2 seconds (panel B).
ably because of poor contact between the ablation catheter and the needle. It may also be explained by the inertia of the RF generator needed to reach the required energy.

Clinical Implication and Safety

The occurrence of resistant septum after more than 1 procedure is increasingly being encountered, and thus, this puncture method is of great practical interest. The major caveat for using RF transseptal technique is to ensure correct positioning of the transseptal needle as inadequate positioning of the needle could result in cardiac tamponade. Our study demonstrates that fluoroscopy and septal contrast injection are reliable methods for ascertaining the correct position of the transseptal needle. Of note, in most cases, contrast remains visible in the septal tissue after injection and this allows for real-time septal visualization while monitoring the pressure during RF transseptal puncture (Figures 1 and 3).

Importantly, the risk of RF use for transseptal puncture has to be balanced against the risk of heart perforation when the needle is forced onto the interatrial septum (with bending of the transseptal apparatus) to try to perforate resistant septae. With forceful attempts at crossing the septum, the needle may slide off the septum or suddenly cross the septum. This can result in inadvertent atrial puncture of either the right (as in one case of our study) or the left atrium. This is particularly true in the case of interatrial aneurysmal septum, where vigorous septal maneuvers could result in the dangerous situation of the interatrial septum and posterior LA wall being in close proximity at the time of puncture. In one animal study, the authors demonstrated that the extent of RF-induced atrial tissue injury was limited and similar to that obtained with the mechanical needle puncture. Therefore, inadvertent atrial puncture with RF (because of incorrect positioning) theoretically has the same consequences as mechanical puncture, although this has not been evaluated in animal studies.

One may hypothesize that transseptal puncture performed with RF energy could result in irreversible tissue damage and lifelong interatrial communication. However, in one animal study, 1 month after RF septal perforation on pigs, the perforations in the septum were closed with well-developed scar tissue and minimal residual inflammation. In our study, 1 patient has required further transseptal catheterization and has been investigated with repeat TEE. In this patient, the previous transseptal hole was already closed 3 months after the first RF transseptal puncture, confirming the spontaneous capability of scarring with this technique.

In some centers, less-experienced transseptal puncture with fluoroscopy was the only imaging tool, other imaging modalities can be used to confirm correct positioning of the transseptal needle in relation to the interatrial septum. Furthermore, if there is any doubt about the correct location of the needle, even after additional imaging modalities have been used, this RF transseptal technique should obviously be avoided.

Care has to be taken concerning the isolation of the needle from the patient and the operator. The patient is protected from RF energy along the needle, thanks to the plastic sheath, while the operator is protected because of not touching the needle with the use of plastic gloves. However, particular attention needs to be taken to make sure that no part of the needle touches the patient’s skin.

Finally, although this study demonstrates the use of unipolar RF delivery in the context of transseptal puncture, this could be applied to several other medical procedures where puncture of luminal structures is required.

Conclusions

Transmission of RF energy from the ablation catheter to the proximal extremity of the needle provides an easy and effective method for piercing the fossa ovalis when the conventional approach fails because of a resistant septum.

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References

The success of catheter ablation for atrial fibrillation has led to a dramatic increase in patients who require left atrial access via a transseptal puncture. However, patients often require multiple procedures, leading to fibrosis of the interatrial septum. It is in this setting that more cases of difficult or even "impossible" transseptal punctures are being encountered with the conventional Brockenborough technique because of a resistant septum. This article describes a novel technique using unipolar radiofrequency energy delivered via the standard ablation catheter to the transseptal needle. This novel technique was successful within a median of 1 second in all patients in whom the conventional technique had failed despite multiple forceful attempts. This practical method should prove a useful addition to the numerous techniques that can be used to puncture the fossa ovalis, providing adequate safety precautions are made to ensure the needle is in contact with the interatrial septum. This technique has the benefit of not requiring excessive force to cross the septum and may reduce the number of complications from resistant transseptal access.
Radiofrequency Puncture of the Fossa Ovalis for Resistant Transseptal Access
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