Acute Pyloric Spasm and Gastric Hypomotility
An Extracardiac Adverse Effect of Percutaneous Radiofrequency Ablation for Atrial Fibrillation
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OBJECTIVES
This study sought to describe a new adverse effect of percutaneous radiofrequency (RF) ablation for atrial fibrillation (AF).

BACKGROUND
Extension of the RF lesion beyond atrial myocardium may affect mediastinal structures other than the esophagus.

METHODS
Circular mapping-guided isolation of the pulmonary veins was performed in two different electrophysiology laboratories, either individually and supplemented by ostial and posterior left atrial (LA) ablation or two by two with a series of ostial and posterior LA lesions. The RF energy was delivered point by point through a 5-mm open-tip irrigated catheter (40 W maximum) or an 8-mm-tip catheter (45 W maximum).

RESULTS
In four (two in each electrophysiology laboratory) of 367 patients undergoing catheter ablation for AF, abdominal pain and distension developed within 48 h after the procedure. Investigation showed acute pyloric spasm and gastric hypomotility, probably the result of LA endocardially delivered RF affecting the periesophageal vagi. Complete spontaneous recovery occurred in two patients, but laparoscopic esophagojunal anastomosis and endoscopic intra-pyloric Botulinum toxin injection, respectively, were performed to remedy delayed gastric emptying in two patients.

CONCLUSIONS
Thermal injury during endocardial LA RF energy delivery may extend into the mediastinum and rarely may involve the periesophageal vagi, resulting in a syndrome of acute delayed gastric emptying. Marked anatomic variability of periesophageal vagi renders it difficult to reliably avoid the area overlying this plexus, therefore, we advocate a reduction in maximum RF power and application duration on all of the posterior LA to try to avoid this complication. (J Am Coll Cardiol 2005;46:327–30) © 2005 by the American College of Cardiology Foundation

Percutaneous catheter-based techniques of sinus rhythm maintenance in patients with atrial fibrillation (AF) are being offered increasingly frequently. The original technique of focal radiofrequency (RF) ablation has been replaced by mapping-guided pulmonary vein (PV) isolation or left atrial (LA) circumferential ablation with higher success rates (1,2). In experimental studies in animals, endocardially delivered RF lesions have been found to extend beyond the myocardium into surrounding tissue (3). The recent description of atrioesophageal fistulas as a complication of intraoperative (4) as well as percutaneous RF ablation (5) has focused attention on the extracardiac penetration of ablative energy. In this paper, we describe the occurrence of acute delayed gastric emptying as a complication of percutaneous catheter ablation of AF.

CASE REPORTS
At the University Hospital of Geneva, Switzerland, a 41-year-old man underwent RF catheter ablation for drug-resistant symptomatic paroxysmal AF after obtaining informed written consent. Ablation was performed under local anesthesia supplemented by deep sedation with intravenous midazolam and morphine. The PV ostia were localized by selective contrast venography, and circular mapping-guided isolation of the four PVs was performed individually as proximally as possible. Additional ablation was extended proximally (into the LA) to involve the junction of ipsilateral PVs. Nine, 6, 6, and 15 min of RF energy were respectively delivered to successfully isolate the left superior, the right superior, the left inferior, and the right inferior PVs and perform ostial ablation. The RF energy was delivered point by point (for 60 s at a given site) using a 5-mm “shower tip” irrigated catheter. Up to 45 W of RF energy was delivered in temperature-controlled (50°C) power-limited mode during irrigation at 20 ml/min with room-temperature saline. The RF power was limited to 35 W at the PV ostia, to 40 W within the adjacent LA, and to 45 W in the cavotricuspid isthmus. The RF delivery in the posterior LA at the right inferior PV ostium produced intense pain despite supplementary morphine boluses and required premature termination of RF delivery. No complications were detected during the procedure, and the patient was discharged on oral anticoagulation and subcutaneous low-molecular-weight heparin injections. About 36 hours later, the patient was rehospitalized for acute bloating. The stomach was found to be distended and atonic on abdominal radiograph. With institution of nasogastric tube drainage, the
symptoms disappeared within one week and the patient was discharged. After 14 months of follow-up, the patient is asymptomatic.

A 65-year-old woman with symptomatic paroxysmal AF (resistant to amiodarone) and no structural heart disease underwent circular mapping-guided PV isolation and ostial ablation as described above. The four PVs were successfully isolated after 8, 13, 10, and 32 min of RF energy (for the left superior, the right superior, the left inferior, and the right inferior PVs, respectively), and block was created in the cavotricuspid isthmus (with 17 min of RF energy). Significant pain occurred during RF delivery in the posterior LA (for right inferior PV isolation) despite administration of additional boluses of morphine and was managed by premature termination of RF delivery. Systemic hypotension (and mild sinus bradycardia) also developed but responded to intravenous atropine and volume administration. No other complications were detected during the procedure. Twenty-four hours later, nausea, epigastric pain, bloating, and belching developed and the patient was unable to eat. Upper gastrointestinal (GI) endoscopy showed no esophageal lesion, a stomach full of food, and pyloric spasm. Barium swallow disclosed an atonic stomach. Endoscopic ultrasonography showed a 5-mm-diameter hypoechoic lesion close to the PVs with an intact esophageal wall (Fig. 1). Gastric emptying time was markedly delayed (half emptying time for liquids, 240 min; normal value <126 min). During upper GI endoscopy, 100 U botulinum toxin type A (Botox, Allergan, Irvine, California) was injected into the pyloric sphincter (6). Symptoms significantly improved, and the patient was able to eat semi-solid food starting 4 h later. Five days later, the half emptying time for liquids had reduced to 159 min. Symptomatic improvement has since been sustained (12 weeks to date), and the patient is able to eat a near-normal diet.

At the Yokosuka Kyusai Hospital in Japan, a 45-year-old man with symptomatic paroxysmal AF resistant to multiple antiarrhythmic drugs underwent extensive PV isolation and ablation of the cavotricuspid isthmus. The procedure was performed under propofol sedation. Using a triple transseptal puncture technique, the ipsilateral PVs were jointly isolated by a continuous lesion encompassing both ostia (two-by-two PV isolation) (7). A linear lesion was created point-by-point on the posterior LA wall, which was then completed (again point-by-point) on its anterior aspect guided by activation recorded on both circular mapping catheters. An 8-mm-tip ablation catheter was used with a temperature-controlled (55°C) maximal RF power of 45 W for the posterior LA and 40 W for the anterior aspect of the PVs; 60 s of RF energy was delivered at a given point; 13 min of RF were required to isolate the right PVs, 11 min for the left PVs, and 5 min for bidirectional conduction block in the cavotricuspid isthmus. No complications were detected during the procedure. Abdominal pain and distension developed 3 to 4 h after the procedure. Endoscopy and an upper GI series showed gastric paresis and pyloric spasm with a gastric emptying time of more than 24 h. Endoscopic balloon dilation of the pyloric sphincter was performed twice, but eventually (six months later) a laparoscopic esophagojejunal anastomosis, partial gastrectomy, and gastro-duodenal anastomosis (of the residual stomach) was performed.

At the same center, a 70-year-old man with paroxysmal AF without structural heart disease and resistant to multiple antiarrhythmic drugs underwent a similar extensive PV isolation procedure. A transient ischemic attack had occurred 14 years earlier and cavotricuspid isthmus ablation had been performed 4 years ago. An esophagogram was performed at the beginning of the procedure, but the ablation technique was not modified to completely avoid the borders of the esophageal lumen. Twelve minutes of RF energy was delivered to isolate the left PV ostia, and 9 min for the right PV ostia. As with the other cases, no complications were detected during the procedure. Two days after the procedure, the patient developed abdominal discomfort followed by distension. Endoscopy showed gastric dilatation with retained food; however, with conservative treatment, the patient was able to resume oral intake gradually, leading to a successful discharge on a normal diet at three weeks.
The clinical presentation of all four patients was very similar and was characterized by abdominal bloating and discomfort occurring within a few hours to two days after the procedure (Table 1). Improvement occurred within two weeks in two patients who eventually recovered completely; on the other hand, an earlier onset of symptoms seemed to correlate with significant residual gastric motor dysfunction. Because pyloric spasm is a prominent component of this syndrome, dilation was performed, mechanically in one patient and by local injection of Botulinum toxin in the other with at least temporary improvement in gastric emptying. It is not clear whether local injection of Botulinum toxin can provide longer-lasting relief; in any case, it would be difficult to exclude spontaneous recovery.

This complication occurred with the open irrigated tip as well as with the 8-mm catheter (both are known to produce larger and deeper lesions than a 4-mm-tip conventional catheter), and preventing it is clearly ideal. Because extra-cardiac penetration of endocardially delivered RF energy is almost certainly the basis of this complication, a strategy of reduced RF power and shorter RF delivery duration at vulnerable sites is advisable. The delivery of 32 min of RF energy around the ostium of the right inferior PV in Patient #2 is more than twice the mean value in our laboratory (unpublished data) and may be responsible for the lesion affecting the periesophageal vagal plexus. The occurrence of severe pain (and systemic hypotension) may reflect extracardiac penetration, but may be non-specific and would be masked by propofol sedation or general anesthesia. Whether alternative ablative modalities such as cryoablation or microwave have a more favorable risk profile is unknown. With the open-tip irrigated catheter and the 8-mm-tip catheter, we currently use a maximum power of 35 W (limited to 45 s duration) at a given site on the posterior LA. This represents a 20% to 25% reduction in power and application duration. However, given the close anatomic proximity of vagal fibers, it is unclear whether this or any reduction in delivered energy will be effective in avoiding this complication without sacrificing efficacy. Although knowledge of the position of the underlying esophagus may be of help, it is not clear to what extent this correlates with the location of relevant nerve fibers. Nerve fibers innervating the pyloric sphincter and the gastric antrum are thought to travel within the left vagal trunk [usually located on the left/anterior portion of the esophagus (8,9)] but may also course within intercommunicating fibers. In 32 cadavers, four broad patterns were described: 11 cases in which the right and left vagi (formed by fibers emerging from the pulmonary plexus) communicated through fibers passing anterior to the esophagus, 1 case without any communication, 6 cases with posterior communications only, and 14 cases with both anterior and posterior communications. However, each cadaver was shown to have a distinctive anatomy, making any predictions impossible (10). Esophagojejunal anastomosis

**Table 1. Salient Patient Details**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age</th>
<th>Gender</th>
<th>Arrhythmia</th>
<th>Ablation</th>
<th>Maximum RF Power</th>
<th>Symptoms</th>
<th>Onset</th>
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<tbody>
<tr>
<td>1</td>
<td>41</td>
<td>M</td>
<td>Paroxysmal</td>
<td>Individual four-PV isolation, ostial ablation</td>
<td>40 W</td>
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<td>36 h</td>
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<td>48 h</td>
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AF = atrial fibrillation; CTI = cavo-tricuspid isthmus; PV = pulmonary veins; RF = radiofrequency.

**DISCUSSION**

This report describes a new extracardiac adverse effect—acute delayed gastric emptying—of catheter ablation of AF. This probably results from left atrially delivered RF energy affecting the periesophageal vagal plexus. These 4 cases occurred among a total of 367 cases (1.08%) performed using the above technique in our two laboratories (170 and 187 cases, respectively), with complete recovery in 2 cases, whereas corrective interventions were required in the remaining 2 cases.

The temporal course of symptoms and delayed gastric emptying clearly indicate that this adverse effect is a sequela of the ablation procedure. Upper GI investigations showed pyloric spasm, gastric hypomotility, and a markedly prolonged gastric half emptying time. The demonstration of a 5-mm hypoechoic lesion (by endoscopic ultrasonography) close to the PVs between the LA and the esophageal wall confirms that endocardially delivered RF energy penetrated into tissue beyond the LA (but without extending into the esophageal wall). Nerve fibers coursing within the periesophageal vagal plexus and innervating the gastric antrum and the pyloric sphincter were very likely affected.

Because pyloric spasm is a prominent component of this syndrome, dilation was performed, mechanically in one patient and by local injection of Botulinum toxin in the other with at least temporary improvement in gastric emptying. It is not clear whether local injection of Botulinum toxin can provide longer-lasting relief; in any case, it would be difficult to exclude spontaneous recovery.

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geal temperature monitoring and avoiding LA endocardium overlying the esophagus (opacified by esophagography during the procedure) may be useful clinical strategies for avoiding injury to the vagal plexus or its components and are under evaluation. Imaging or identification of periesophageal vagi (which may not correspond to the esophageal lumen) and/or titrating RF energy with respect to the local myocardial thickness and surrounding structures (11) may ultimately be necessary to avoid extracardiac complications. Cardiac denervation ablation strategies may also need to distinguish target nerves from innervation to the stomach and pylorus.

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REFERENCES


