Linear atrial lesions should always be performed in addition to circumferential pulmonary vein isolation.

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Linear lesions are the equivalent of surgical atriotomies created by percutaneous catheter ablation, but in electrophysiological terms should be considered complete only if they create complete conduction block across two fixed or anatomic obstacles. Linear lesions increase the activation time of the atrium by enforcing a detour depending upon the site of impulse origin. By changing the sequence of activation of the atria they may alter electromechanical feedback. Depending upon the type and number of lesion(s) deployed, linear lesions can also debulk the atria. Theoretically, complete linear lesions should be the least pro-arrhythmic means of achieving debulking. They may also eliminate areas of slow conduction and affect the substrate of atrial fibrillation by modifying pivot points. If the linear lesions are incomplete, they may produce conduction delay and contribute to arrhythmogenicity.

Pulmonary vein isolation or encircling has been shown to be effective in eliminating atrial fibrillation in many patients. However, success rates for the elimination of persistent or permanent atrial fibrillation are consistently lower. In particular, circular mapping-guided percutaneous pulmonary vein isolation with radiofrequency (RF) energy and surgical open heart cryoablation have both led to disappointing initial results and high recurrence rates. Adjunctive linear left atrial lesions may improve results of curative ablation of persistent and permanent atrial fibrillation (AF).

In order to evaluate the mechanism of linear lesions and their effectiveness, we prospectively studied consecutive patients undergoing catheter ablation for drug-resistant and symptomatic atrial fibrillation. In view of the

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effectiveness of pulmonary vein isolation alone in patients with paroxysmal atrial fibrillation, adjunctive linear lesions were delivered only in patients with persistent or permanent atrial fibrillation.

**Methods**

Circular mapping-guided pulmonary vein (PV) isolation was performed followed when necessary by one or two linear lesions in the left atrium (LA) with irrigated-tip RF ablation (35–40 W max. for PVs, 45 W max. for linear lesions). Linear lesions were deployed from the left PV ostia to the posterolateral mitral annulus, and from the left to the right PV ostia guided by electroanatomic mapping. Their electrophysiology (EP) was assessed after ablation by complete electroanatomic mapping of the LA during distal coronary sinus pacing and correlated with rhythm outcome.

**Results**

Thirty-nine patients with persistent or permanent atrial fibrillation (5 with structural heart disease; 4 female patients; age 57 ± 10 years) underwent isolation of all PVs (n = 155). Cavotricuspid isthmus ablation was performed in 7 and linear LA ablation in 28 patients. The lesion from the left PV to the mitral annulus (27 ± 8 mm length, 14 ± 7 min RF) was incomplete in 14/28, with marked slow conduction in 5. The lesion from the left PV to the right PV (34 ± 10 mm, 11 ± 5 min RF) was incomplete in 9/23, with marked slow conduction in 3. Seventeen patients underwent reablation for recurrent atrial fibrillation (n = 10) or new-onset atrial flutter (n = 10). PV conduction recovery was observed in 12, while narrow channels near PV ostia acted as critical isthmuses of LA flutter in 8 (including 3 with complete linear lesions) and were successfully ablated. After a follow-up of 18 ± 8 months (range 6–37), 30/39 (77%) maintained stable sinus rhythm without anti-arrhythmic treatment. Nine of 12 with PV isolation alone, 9/10 patients with both linear lesions complete, and 12/17 patients with one or both linear lesions incomplete were in stable sinus rhythm.

**Conclusions**

1. Subsets of patients with persistent AF can be cured with PV isolation alone while others with persistent or permanent AF derive similar benefit from linear lesions. The challenge facing us is to identify those subsets of patients who benefit from supplementary linear lesions – such as those