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SHORT COMMUNICATION

Mechanisms of atrial flutter following epicardial high intensity focused ultrasound left atrial ablative procedures during concomitant cardiac surgery

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KEYWORDS

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Abstract *Introduction:* Iatrogenic atrial tachyarrhythmias have increased with the widespread application of left atrial ablative procedures to treat atrial fibrillation.
Methods and results: Entrainment and activation mapping were utilized to study the mechanisms of atrial flutter in two patients who presented with atypical atrial flutter after high intensity focused ultrasound (HIFU) atrial ablation for persistent atrial fibrillation during the course of concomitant cardiac surgery. *Case 1:* Atrial flutter with CL of 340 ms was demonstrated to be mediated by entry into and exit from the partially isolated posterior left atrium (LA) with conduction delay across at least one of the connections. The exit site was near the left superior pulmonary vein (LSPV) and the entrance site was near the right inferior pulmonary vein (RIPV) as demonstrated by activation and entrainment mapping. *Case 2:* Entrainment mapping was highly suggestive of inferior exit from the HIFU ablation line between the two inferior pulmonary veins. Flutter terminated during

Abbreviations: HIFU, high intensity focused ultrasound; LA, left atrium; AF, atrial fibrillation; ECG, electrocardiogram; AV, atrio-ventricular; TTE, trans-thoracic echocardiography; LVH, left ventricular hypertrophy.; CS, coronary sinus; HRA, high right atrium; CTI, cavo-tricuspid isthmus; PPI, post-pacing interval; TCL, tachycardia cycle length; RF, radiofrequency; LSPV, left superior pulmonary vein; LIPV, left inferior pulmonary vein; RIPV, right inferior pulmonary vein

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trans-septal procedure and could not be re-induced. Activation mapping of the LA during pacing revealed the inferior exit and left superior entrance site, both of which were successfully ablated, isolating the posterior LA.

Conclusions: Re-entrant atrial flutter post-HIFU epicor Maze is caused by slow conduction at entry and exit sites from the otherwise isolated posterior LA wall. In both cases, gaps were found close to the LSPV and RIPV which may reflect difficulty in achieving proper contact between the HIFU device and the left atrial wall at these sites. These gaps are amenable to catheter ablation.

1. Introduction

In 1998, Haissaguerre et al. demonstrated that pulmonary vein ectopics are the most important triggers initiating atrial fibrillation especially in patients with the paroxysmal form of this disorder.[1] Since that time, different energy sources including radiofrequency,[2] microwave,[3] laser,[4] cryotherapy[5] and high intensity focused ultrasound (HIFU) have been developed and tailored to encircle the pulmonary veins from either an endocardial or epicardial approach. The technology using therapeutic HIFU (St. Jude Medical, Inc, Minneapolis, MN) consists of an array of ultrasonic transducers, applied to the epicardial side of the left atrium (LA) encircling the base of the pulmonary vein orifices and delivering energy that creates linear ablation lesions.[6]

The incidence of iatrogenic atrial tachyarrhythmias has raised rapidly with the widespread practice of these LA surgical or catheter-based ablation procedures to treat atrial fibrillation (AF). Although some groups have reported focal mechanisms as the most common etiology,[7] others have reported macro-reentry as the most common mechanism.[8] Slow conduction over gaps in previously performed ablation lines (where conduction has recovered) is the most likely substrate for these flutter circuits. We report two cases of left atrial flutter following a left atrial surgical epicardial ablative procedure for treatment of AF utilizing HIFU.

2. Methods

2.1. Patients' characteristics

We studied two patients who presented with atypical atrial flutter. Both patients had previously undergone left atrial epicardial ablation for treatment of persistent atrial fibrillation utilizing HIFU during the course of concomitant cardiac surgery. The standard HIFU procedure described previously was performed in both cases.[9,10] Ablation was carried out using the Epicor HIFU ablation system which consists of an array of transducers (Ultracinch) positioned on the epicardium after proper sizing around the four PVs, over the antral portion of the LA wall to create a box lesion set that aims at isolating the 4 PVs and the posterior LA. The transducer was flushed with saline prior to energy delivery. The automated energy delivery setting was used on both cases for approximately 10 min. In both cases, no mitral isthmus line was performed and acute isolation was not assessed. Case 1 is a 63 year-old male who presented with dyspnea 6 months after mitral valve repair for severe mitral regurgitation together with left atrial appendectomy. Electrocardiogram (ECG) showed atrial flutter with 2:1 AV conduction. Flutter wave morphology was positive in the inferior leads and in V1, and negative in leads I and AVL with a cycle length of 340 ms (Fig. 1). Trans-thoracic echocardiography (TTE) showed moderate impairment of left ventricular systolic function. He was maintained on Amiodarone and warfarin targeting therapeutic INR (2–3). Case 2 is a 67 year-old hypertensive patient who presented with palpitations and dyspnea one year after he underwent 3-vessel coronary artery bypass grafting with HIFU left atrial ablation. He was cardioverted several times for highly symptomatic atrial flutter episodes with rapid ventricular response despite beta-blockade. ECG showed atrial flutter with variable AV block and voltage criteria of left ventricular hypertrophy (LVH). Flutter wave morphology was negative in the inferior limb leads and in lead I, isoelectric in AVL and positive in V1 with a cycle length of 260 ms (Fig. 2). TTE showed moderate concentric LVH, basal inferior hypokinesis and mild reduction of the global left ventricular systolic function. He was maintained on antiischemic measures including B-blockers in addition to Amiodarone and warfarin targeting therapeutic INR. In both patients, a trans-esophageal echocardiography ruled out left atrial thrombus.

2.2. Electrophysiology studies

After informed consent, the patients underwent electrophysiology studies in the fasting state under conscious sedation. Multipolar electrode catheters were inserted into the femoral veins. A quadripolar catheter was advanced to the right ventricular apex. A deflectable Multipole catheter (Duodecapolar catheter) was placed with its distal end in the coronary sinus (CS) and its proximal part overlying the cavo-tricuspid isthmus (CTI) and the lateral right atrial free wall. An irrigated 3.5 mm tip deflectable catheter with a three-dimensional mapping system was used for mapping [Ensite-Navx (St. Jude Medical, Inc, Minneapolis, MN) for the first case and Carto XP (Biosense Webster, Diamond Bar, CA, USA) for the second case]. Bipolar intra-cardiac electrograms were filtered between 30 and 500 Hz and stored on a multichannel recorder (The Prucka, Cardiolab, GE, Inc.).

3. Results

Case 1: The atrial flutter cycle length was 340 ms. Entrainment mapping from the high right atrium (HRA), cavo-tricuspid isthmus (CTI), proximal, middle, and distal CS resulted in out-of-circuit responses [post-pacing interval (PPI) was much greater than tachycardia cycle length (TCL)]. Entrainment from the mid-posterior right atrial septum showed a PPI–TCL of 20 ms. Mapping of the RA revealed activation propagating from the superior septum, consistent with activation