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Original Article

Impact of ganglionated plexi ablation on high-frequency stimulation-induced changes in atrial fibrillation cycle length in the pulmonary vein

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ABSTRACT

Background: We assessed high-frequency stimulation (HFS)-induced changes in the atrial fibrillation (AF) cycle length (AFCL) in the pulmonary vein (PV) after ganglionated plexi (GP) ablation.
Methods: Twenty-two patients undergoing catheter ablation for AF were retrospectively enrolled. Sites showing a vagal response (VR) to HFS were defined as GP-positive sites. AFCL was determined in the adjacent PV, distant PV, coronary sinus, and right atrium. Twenty cycles were counted before and after each HFS. After radiofrequency application to the GP site, HFS was repeated.
Results: At GP-positive sites ($n=57$), significant shortening of the AFCL was detected in the adjacent PV (17% shortening, 165 ± 38 to 137 ± 27 ms, $p < 0.001$) and distant PV (4.8% shortening, $p < 0.001$), but not in the coronary sinus (0.8% shortening, $p=0.27$) or right atrium (1.8% shortening, $p=0.06$). However, no significant shortening was observed at GP-negative sites ($n=25$). At 41 of the 57 sites where VR disappeared after a single radiofrequency application, no significant shortening was observed in the adjacent PV (2.1% shortening, $p=0.25$). At 16 of the 57 sites where VR was still present, significant shortening was observed in the adjacent PV (16% shortening, $p < 0.001$).
Conclusions: HFS of the GP has a strong influence on AFCL in the PV.

1. Introduction

Autonomic influences in the heart are generated by both the extrinsic and intrinsic cardiac autonomic nervous system (ganglionated plexi; GP) [1,2]. Experimental and clinical studies suggest that GP activation plays a significant role in the initiation and maintenance of atrial fibrillation (AF) [3–5]. In an animal model, stimulation of the GP produces repetitive short bursts of rapid, irregular firing in the adjacent pulmonary vein (PV); these bursts initiate sustained AF. Recent clinical studies have demonstrated that the combination of GP ablation and PV isolation produces a better outcome than PV isolation alone [6,7]. These findings indicate a relationship between GP activation and PV activation during clinical AF. However, it is unclear whether GP stimulation alters AF cycle length (AFCL) in the PV before and/or after GP ablation. In the present study, we assessed whether high-frequency stimulation (HFS)-induced changes in AFCL in the PV occur before or after GP ablation.

2. Methods

2.1. Patient characteristics

We retrospectively analyzed 22 AF patients (10 with paroxysmal AF, 12 with persistent AF) undergoing catheter ablation. The mean age was 58 ± 10 years (4 women). All patients were studied in a fasted state, and all antiarrhythmic drugs were stopped 5 half-lives before the procedure. Eleven patients had hypertension. None of the patients had a history of open-heart surgery. All patients provided written informed consent.

2.2. Study and ablation protocol

A 6-Fr multipolar catheter (Inquiry Wide Band, St. Jude Medical, Irvine, CA) was inserted into the coronary sinus (CS) and right atrium (RA) via the internal jugular vein and RA. A quadripolar catheter with electrodes was advanced into the apex of the right ventricle. Following transseptal puncture, two 7-Fr duodecapolar circumferential catheters (Inquiry Optima, St. Jude Medical) were placed within the ipsilateral superior and inferior PVs under selective PV venography guidance.

A 3.5-mm irrigated-tip catheter (ThermoCool, Biosense Webster, Diamond Bar, CA) was used for mapping and ablation. Electroanatomic mapping of the left atrium and PV was performed using

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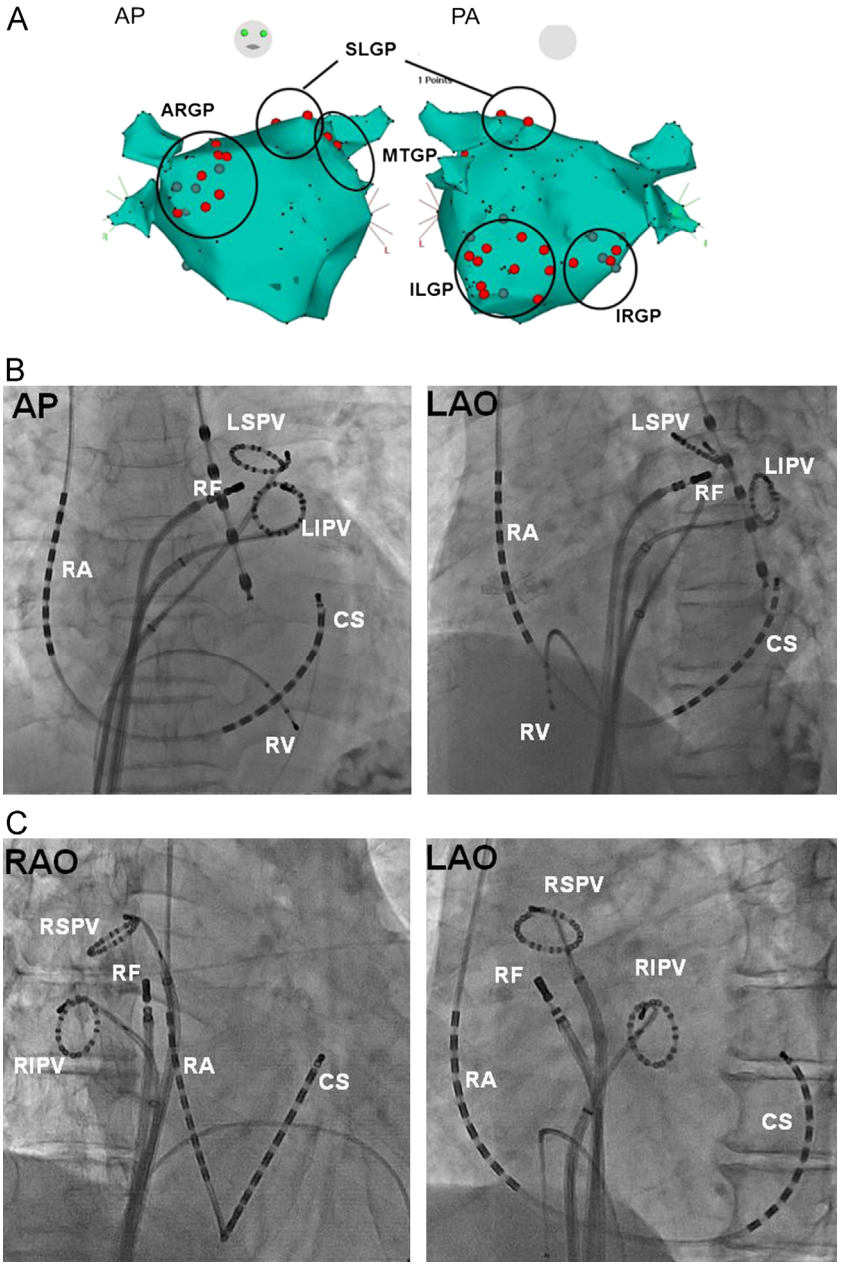

Fig. 1. (A) Location of ganglionated plexi in the left atrium. The Marshall tract ganglionated plexi (MTGP) area is located within the fat pad anterior to the left superior PV and left inferior PV (between the PVs and left atrium appendage). The superior left GP (SLGP) area is located on the roof of the left atrium, medial to the left superior PV. The inferior left GP (ILGP) area is located inferior to the left inferior PV. The anterior right GP (ARGP) area is located anterior to the right superior PV. The inferior right GP (IRGP) area is located inferior to the right inferior PV. AP: anteroposterior view, PA: posteroanterior view. (B,C) Fluoroscopic view of the ablation catheter and the other catheter. (B) When HFS and radiofrequency energy were applied to the Marshall tract GP (MTGP) and superior left GP (SLGP), the circumferential catheters were in the LSPV and LIPV. AP: anteroposterior view, LAO: 55° left anterior oblique view. CS: coronary sinus, RA: right atrium, LSPV: left superior pulmonary vein, LIPV: left inferior pulmonary vein, RF: mapping and ablation catheter, RV: right ventricle. (C) When we applied the HFS and radiofrequency energy to the ARGP, the circumferential catheters were in the RSPV and RIPV. RAO: 30° right anterior oblique view, LAO: 55° left anterior oblique view. CS: coronary sinus, RA: right atrium, RSPV: right superior pulmonary vein, RIPV: right inferior pulmonary vein, RF: mapping and ablation catheter.

the CARTO XP system (Biosense Webster). We induced and maintained sedation using intravenous dexmedetomidine. Thiopental sodium was added depending on the patient's sedation level. The mapping catheter was positioned at the presumed GP site, and HFS was delivered. If sinus rhythm was present at baseline, atrial burst pacing was performed to induce AF. Previous reports have demonstrated that the GP can be identified and localized using endocardial HFS in patients undergoing catheter ablation for AF [8]. We delivered HFS with a frequency of 20 Hz, amplitude of 20 V, and pulse duration of 10 ms (BC-1100, Fukuda Denshi, Tokyo, Japan) for 5 s. A GP-positive site was defined as a site showing a vagal response (i.e., prolongation of the R–R interval by $>50\%$ during AF); a GP-negative site was a site that did not produce a vagal response. We identified the 5 major GP in the left atrium (Fig. 1A). To minimize loss of vagal response, GP ablation was performed in the following order: Marshall tract GP (MTGP), superior left GP (SLGP), anterior right GP (ARGP), inferior left GP (ILGP), and inferior right GP (IRGP) [4].

1. HFS was delivered to the presumed GP site.
2. Radiofrequency energy (30–35 W for 30–40 s) was delivered to GP-positive sites.