Journal of Arrhythmia ■ (■■■■) ■■■–■■■

Contents lists available at ScienceDirect

Journal of Arrhythmia

journal homepage: www.elsevier.com/locate/joa

Original Article

The utility of atrial pacing for identifying the electrical breakthrough sites between the left atrium and pulmonary veins

Shinya Sugiura, MD[a,*], Koji Matsuoka, MD[a], Hideki Noda, BHS[a], Naoya Kurata, BHS[a], Misa Uemori, BHS[a], Hirokazu Shioji, MD[a], Akihiro Takasaki, MD[a], Takafumi Koji, MD[a], Takashi Tanigawa, MD[a], Masaaki Ito, MD[b]

[a] Department of Cardiology, Matsusaka Chuo Hospital, 102 KawaimachiKobou, Matsusaka, Mie 515-8566, Japan
[b] Department of Cardiology and Nephrology, Mie University Graduate School of Medicine, 2-174 Edobashi, Tsu, Mie 514-8507, Japan

ARTICLE INFO

Article history:
Received 28 April 2016
Received in revised form
26 July 2016
Accepted 8 August 2016

Keywords:
Atrial fibrillation
Catheter ablation
Electrical breakthrough sites
Circumferential pulmonary vein isolation

ABSTRACT

Background: Circumferential pulmonary vein (PV) isolation for atrial fibrillation (AF) is occasionally difficult to achieve because electrical breakthrough sites (EBSs) between the left atrium (LA) and PVs cannot be identified during ablation especially in the carina regions.
Methods: The left PVs (Lt.PVs) of 60 AF patients and the right PVs (Rt.PVs) of 37 patients undergoing PV isolation were studied. When PV isolation was not achieved after the initial circumferential PV isolation, atrial pacing was repeatedly performed from the distal coronary sinus (CSd) and high right atrium (HRA), and the time interval from the stimulus to the earliest PV potential (stimulus-PV interval) was measured using circular mapping catheters at each PV until PV isolation was achieved. When PV isolation was achieved via local Radiofrequency (RF) deliveries, those regions were diagnosed as final EBSs. We classified the final EBSs into six segments for each PV (anterior and posterior PV walls of the roof, carina, and bottom) and investigated the relationship between the final EBSs and stimulus-PV intervals.
Results: For Lt.PVs, the stimulus-PV intervals during CSd pacing were significantly shorter than during HRA pacing at the Lt.PV anterior carina and bottom (90 ± 28 ms vs. 125 ± 26 ms, $P < 0.001$ and 84 ± 20 ms vs. 148 ± 24 ms, $P = 0.028$, respectively), but there was no significant difference in the Lt.PV roof and any posterior segments. For Rt.PVs, the stimulus-PV interval from both pacing sites exhibited no significant difference between either segment.
Conclusions: This pacing method may help to identify whether EBSs are located in the anterior Lt.PVs. Improved recognition of EBSs through pacing from different sites would be helpful for achieving PV isolation.

1. Introduction

Circumferential pulmonary vein (PV) isolation has been accepted by a consensus as the strategy for the treatment of atrial fibrillation (AF) using catheter ablation [1–4]. However, in some cases, it is difficult to achieve circumferential PV isolation because the electrical breakthrough sites between the left atrium (LA) and PVs during ablation cannot be identified, especially in the carina regions of each PV even though two circular mapping catheters are used and mapping of the earliest PV potentials is performed.

A few reports have demonstrated how to detect the electrical breakthrough sites between the LA and PVs [5,6]. However, there is no easy and useful method for achieving this. The objective of this study was to investigate the utility of atrial pacing for identifying the electrical breakthrough sites between the LA and PVs, especially in the carina regions of each PV.

2. Materials and methods

2.1. Study population

A total of 102 patients (31 women, 71 men, 63 ± 12 years) with drug-refractory, paroxysmal, or persistent AF who underwent circumferential PV isolation from January 2014 to March 2015 were enrolled. AF was classified according to the HRS/EHRA/ECAS 2012 Consensus Statement on the Catheter and Surgical Ablation of AF [7]. All patients gave their written informed consent and the study protocol was approved by the hospital's institutional review board.

* Corresponding author. Fax: +81 59 821 9555.
E-mail address: urasugi30@gmail.com (S. Sugiura).

http://dx.doi.org/10.1016/j.joa.2016.08.004

In this study, when PV isolation was not achieved after the initial circumferential PV ablation, to detect the electrical breakthrough sites between the LA and PVs, we repeatedly performed pacing from two different sites; the distal portion of the coronary sinus (CSd) and high right atrium (HRA), and measured the time interval from the stimulus to the earliest PV potential (stimulus-PV interval) on the circular mapping catheters at each PV until PV isolation was achieved. Therefore, we excluded patients with the following findings: (i) AF was sustained during catheter ablation even after electrical cardioversion was performed, (ii) the coronary sinus catheter could not be inserted into the vicinity of the left atrial appendage (LAA), (iii) PV isolation could be achieved after the initial circumferential PV ablation, and (iv) the atrium could not be captured by CSd or HRA stimulation. Consequently, the left PVs (Lt.PVs) of 60 patients and the right PVs (Rt.PVs) of 37 patients were investigated in this study.

2.2. Electrophysiological studies and catheter ablation

Antiarrhythmic drugs (AADs) were discontinued at least 5 half-lives prior to the procedure for paroxysmal AF but were continued for persistent AF. All patients were effectively anticoagulated with warfarin or non-vitamin K antagonist oral anticoagulants (NOACs) for at least 1 month before the procedure, and therapeutic anticoagulation was maintained with intravenous heparin following the discontinuation of NOACs 2 days prior to the procedure. Warfarin was continued during the perioperative period. Transesophageal echocardiography was performed within 24 h before the procedure to exclude any atrial thrombi. Cardiac enhanced computed tomography was performed for the evaluation of the relevant cardiac anatomy before the procedure.

The surface and intracardiac electrocardiograms were digitally recorded and stored (Lab System TM PRO EP Recording System, Bard Clearsign™, Boston Scientific Corporation). The bipolar electrograms were filtered from 30 to 500 Hz. A 6-Fr 20-pole three-site mapping catheter (BeeAT, Japan Lifeline, Tokyo, Japan) was passed through the right jugular vein for pacing, recording, and internal cardioversion. The four proximal electrodes, eight middle electrodes, and eight distal electrodes were in the HRA as close as possible to the sinus node, lateral right atrium, and CSd as close as possible to the LAA, respectively, throughout the procedure. The LA was accessed via a patent foramen ovale, when present, or via a transseptal puncture (through an 8-F long sheath; SL0, AF Division, St. Jude Medical, Minneapolis, MN, USA). Before the transseptal puncture, 3000 IU of heparin was administered and 5000 IU of heparin was administered after the transseptal puncture. Heparin was additionally administered to maintain the activated clotting time at 300–350 s. Two circular mapping catheters (Lasso, Biosense Webster, Inc. or Libero, Japan-Lifeline) were placed in the superior and inferior PVs, and the left- and right-sided ipsilateral PV ostia; and the left- and right-sided ipsilateral PVs were circumferentially and extensively ablated guided by a 3-D mapping system (CARTO3 system; Biosense-Webster). When AF occurred before or during the ablation, sinus rhythm was recovered using electrical cardioversion. The electrophysiological endpoint of the PV isolation was the achievement of a bidirectional conduction block between the LA and PVs. Radiofrequency catheter ablation was performed point-by-point using an open irrigated catheter (ThermoCool Smarttouch, Biosense-Webster) with the power and temperature limited to 20–35 W and 43 °C, respectively. The esophageal temperature was measured (using Sensitherm, St. Jude Medical or Esophaster, Japan-Lifeline) during the applications to avoid any esophagus-related complications [8–10], and the Radiofrequency (RF) energy delivery was stopped if the esophageal temperature reached 40 °C. After completing the PV isolation, a 20–40 mg bolus of adenosine triphosphate and 5–20 μg/min of

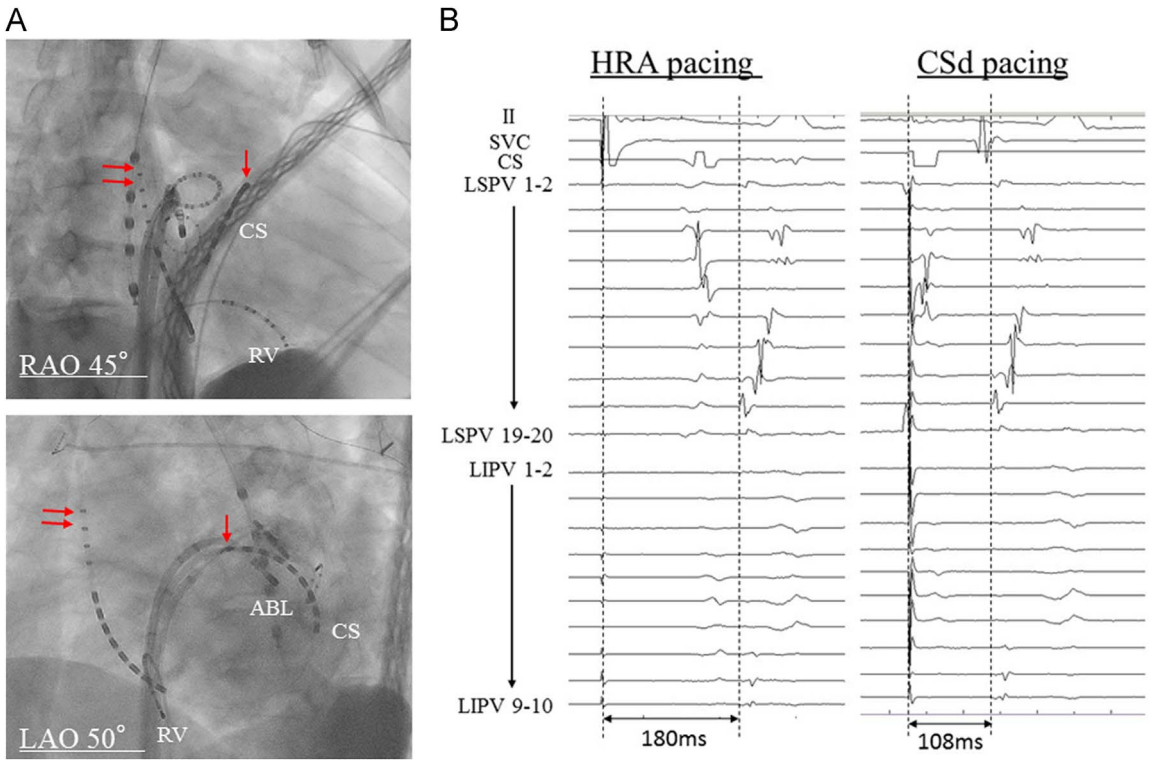

Fig. 1. (A) Fluoroscopic images of the left pulmonary vein (PV) during ablation. Two circular mapping catheters were placed in the ipsilateral left PVs. Pacing was performed from the distal coronary sinus (CSd; arrow) and high right atrium (HRA; two arrows). The ablation catheter (ABL) was placed at the successful site in the anterior region of the LIPV. (B) Intracardiac recordings during HRA pacing and CSd pacing in the same case as (A). The stimulus-PV interval during CSd pacing was shorter than that during HRA pacing (108 ms vs. 180 ms). *LAO* left anterior oblique; *RAO* right anterior oblique; *CS* coronary sinus; *RV* right ventricular; *ABL* ablation catheter; *LSPV* left superior pulmonary vein; *LIPV* left inferior pulmonary vein, *SVC* superior vena cava.

Please cite this article as: Sugiura S, et al. The utility of atrial pacing for identifying the electrical breakthrough sites between the left atrium and pulmonary veins. J Arrhythmia (2016), http://dx.doi.org/10.1016/j.joa.2016.08.004