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Original Article

Usefulness of non-contact mapping for catheter ablation of ventricular tachycardias originating at the right ventricular outflow tract

Tadashi Hoshiyama, MD, Hiroshige Yamabe, MD, PhD, FJCC*, Junjiroh Koyama, MD, PhD, Hisanori Kanazawa, MD, Miwa Ito, MD, Hisao Ogawa, MD, PhD, FJCC

Department of Cardiovascular Medicine, Graduate School of Medical Sciences, Kumamoto University, 1-1-1 Honjo, Kumamoto 860-8556, Japan

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ABSTRACT

Background: Different QRS morphologies are often observed in idiopathic ventricular tachycardias or premature ventricular contractions originating from the right ventricular outflow tract (RVOT). However, the precise mechanism underlying multiple QRS morphologies has not been clarified adequately. The purpose of this study was to examine the mechanism underlying different QRS morphologies in RVOT arrhythmia. We also investigated the usefulness of non-contact mapping guided radiofrequency catheter ablation for RVOT arrhythmia.

Methods: Endocardial mapping of RVOT was performed using a non-contact mapping system in 20 patients with RVOT arrhythmia. We analyzed the underlying mechanism that produces different QRS morphologies during catheter ablation of RVOT arrhythmia.

Results: Forty-six QRS morphologies of RVOT arrhythmia were observed in 20 patients. Five patients showed monofocal QRS morphology, whereas the remaining 15 patients showed multiple QRS morphologies (from 2 to 4 morphologies each). Among these, all patients presented a shift in the origin of tachycardia. Additionally, different QRS morphologies were observed in 5 of these patients that were caused by a change in the local activation after radiofrequency energy delivery. Radiofrequency energy application to the site of origin of the RVOT arrhythmia using non-contact mapping navigation eliminated the RVOT arrhythmias in all patients. However, 1 patient presented a recurrence of RVOT arrhythmia (success rate, 95.0%).

Conclusions: The multiple QRS morphologies of RVOT arrhythmia were caused by a shift in the origin of tachycardia or by a change in the local activation following the radiofrequency energy application. Non-contact mapping was useful to identify the appropriate target site of RVOT arrhythmia irrespective of the changes in QRS morphologies.

1. Introduction

Idiopathic ventricular tachyarrhythmia originating from the right ventricular outflow tract (RVOT) is one of the most frequent ventricular arrhythmias observed in clinical practice [1]. Although RVOT arrhythmias rarely cause sudden cardiac death [2–4], frequent RVOT arrhythmias can reduce left ventricular contraction in some patients [5,6]. Therefore, radiofrequency catheter ablation (RFCA) of RVOT arrhythmia is important, especially for symptomatic patients or those with reduced left ventricular contraction. Moreover, high success rates have been achieved with RFCA, and it is associated with a low risk of complications [7,8].

On the other hand, various QRS morphologies have often been observed in patients with RVOT arrhythmia at the time of RFCA. It has been suggested that a shift in the site of origin of RVOT arrhythmia results in different QRS morphologies [9–11]; however, the precise mechanism underlying multiple QRS morphologies has not yet been clarified.

The purpose of this study was to investigate the mechanism underlying multiple QRS morphologies of RVOT arrhythmias using a non-contact mapping system. In addition, we also investigated the usefulness of non-contact mapping-guided RFCA for RVOT arrhythmias.

2. Methods

2.1. Patient population

Between April 2007 and October 2013, 20 patients who had undergone RFCA for RVOT arrhythmias were included in this

Abbreviations: PVC, premature ventricular contraction; RFCA, radiofrequency catheter ablation; RVOT, right ventricular outflow tract

* Corresponding author. Tel.: +81 96 373 5175; fax: +81 96 362 3256.
E-mail address: yyamabe@kumamoto-u.ac.jp (H. Yamabe).

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study. The study protocol was approved by the Human Research Committee of Kumamoto University Hospital, and written informed consent was obtained from each patient.

2.2. Electrophysiological procedure and image acquisition

All antiarrhythmic drugs were discontinued for at least five half-lives before the catheter ablation procedure. None of the patients were treated with amiodarone. A 6-Fr quadripolar electrode catheter (St. Jude Medical, St. Paul, MN, USA) was inserted percutaneously and was positioned in the right ventricular apex. Subsequently, a 9-Fr multielectrode array catheter (EnSite 3000; St. Jude Medical, St. Paul, MN, USA) was introduced into the RVOT via the 10-Fr sheath, deployed on a 0.032-in. guide wire with its distal tip fixed in the pulmonary artery. Bipolar electrograms were filtered between 50 and 600 Hz and recorded along with the surface electrocardiogram using a polygraph (EP-workmate; EP Med. Systems, Inc., Mt Arlington, NJ, USA).

2.3. Non-contact mapping system

Endocardial mapping of the RVOT was performed using a non-contact mapping system. The detail of the non-contact mapping system has been described previously [11,12]. In brief, the system utilizes a non-contact mapping catheter that contains 64 filaments with a 0.025-in. insulation break at specified sites to form a multielectrode array. Additionally, it allows high-resolution simultaneous activation maps of the entire cardiac chamber from just one beat of ventricular tachycardia or PVC.

2.4. Study protocol

Electrophysiological studies and subsequent RFCA were performed under fasting conditions. If RVOT arrhythmia did not occur spontaneously, continuous infusion of isoproterenol (1–3 μg/min) was administered. Endocardial mapping of the RVOT was performed. Subsequently, the origin and activation sequence of all of the QRS morphologies of RVOT arrhythmias that appeared during the procedures were analyzed. Radiofrequency energy was delivered to the earliest ventricular activation site showing RVOT arrhythmia. If an RVOT arrhythmia site was different from the one that was initially targeted after radiofrequency energy application, endocardial mapping of the RVOT was performed again. A change in QRS morphology was defined as any change in the amplitude, width, or vector of the QRS complex. RFCA guided by non-contact mapping was performed targeting the earliest ventricular activation site of RVOT arrhythmia. A 7-Fr, 8-mm tip, conventional ablation catheter (Fantasista: Japan Lifeline, Tokyo, Japan) or a 7-Fr large-tip (3.5 mm in length) irrigated ablation catheter (Cool Path Duo; St. Jude Medical, St. Paul, MN, USA) were used for ablation. Non-irrigated radiofrequency energy application was delivered up to 45 W for up to 180 s. Irrigated radiofrequency energy application was delivered up to 45 W for up to 120 s, with an irrigation flow rate of 13–16 mL/min. When the catheter manipulation was prevented because of the multielectrode array catheter, we deflated the multielectrode array from full volume to a size that fit into the RVOT to allow maneuvering of the catheter.

2.5. Statistical analysis

Values are expressed as mean ± standard deviation. A *P* value of <0.05 was considered statistically significant. The Shapiro–Wilk test showed skewed data. Differences between means were tested by the Mann–Whitney test. All statistical analyses were performed using SPSS (IBM; version 17, Armonk, NY, USA).

3. Results

Table 1 shows patients' characteristics. There were 5 men and 15 women, with a mean (± standard deviation) age of 55 ± 21 years (range, 15–77). Eleven patients had nonsustained ventricular tachycardia, and 9 patients had premature ventricular contraction (PVC). No structural heart disease was detected using transthoracic echocardiography. Forty-six QRS morphologies of RVOT arrhythmia were observed in the 20 evaluated patients. The site of origin could be identified using the non-contact mapping system in all the patients. Five patients showed monofocal QRS morphology, whereas the remaining 15 patients showed multiple QRS morphologies (from 2 to 4 morphologies each, Table 1). The mean distance between the initial site of origin and the subsequent different sites of origin of RVOT arrhythmia was 9.9 ± 7.1 mm.

Table 1
Patients' characteristics.

Patient	Age	Sex	Arrhythmia	Total number of QRS morphology	Cause of QRS morphology change		Outcome
					Shift in origin	Change in the local activation	
1	71	F	NSVT	4	3	1	Success
2	54	F	NSVT	4	4	0	Success
3	49	F	PVC	1	1	0	Success
4	17	F	NSVT	3	3	0	Success
5	70	F	PVC	1	1	0	Success
6	58	F	PVC	1	1	0	Success
7	51	F	PVC	1	1	0	Success
8	76	F	NSVT	3	2	1	Success
9	15	M	NSVT	2	2	0	Success
10	50	M	PVC	3	2	1	Success
11	67	F	NSVT	2	2	0	Success
12	16	F	PVC	2	2	0	Success
13	44	F	PVC	2	2	0	Success
14	63	M	NSVT	3	3	0	Success
15	74	M	NSVT	2	2	0	Success
16	22	F	PVC	2	2	0	Success
17	77	F	NSVT	3	2	1	Success
18	70	M	NSVT	3	2	1	Recurrence
19	75	F	NSVT	1	1	0	Success
20	72	F	PVC	3	3	0	Success
Total				46	41	5	