Ultra-high Density Atrio-Ventricular Dual Chamber Mapping, as a Next Generation Tool for the Ablation of Accessory Pathways

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Abstract

Introduction Detail 3D mapping have been useful for effective radiofrequency catheter ablation. Rhythmia system can create the atrio-ventricular dual chamber mapping, which reveals the atrial and ventricular potentials all at once in the same map. The aim of this study was to investigate the utility of Rhythmia system for catheter ablation of accessory pathways (AP). Methods From July 2015 to August 2020, 111 patients underwent ablation of APs. The dual chamber mappings were created in 50 patients [median age 15 (10-54), 32 male(64.0%)], while 61 patients underwent the radiofrequency (RF) ablations with conventional single chamber 3D mappings. The background characteristics and procedure details were compared between the dual chamber mapping group and conventional single chamber mapping group. Results The number of RF application [1 (1-3) vs 3 (1-6), p=0.0023], RF time [9.2 (2.0-95.7) vs 95.6 (4.1-248.7), p=0.0023], RF energy [248.4 (58.7-3328.2) vs 2867.6 (134.2-7728.4), p=0.0115] were significantly lower in dual chamber group. Fluoroscopy time [19.9 (14.2-26.1) vs 26.5 (17.7-43.4), p=0.0025], and fluoroscopy dose [52.5 (31.3-146.0) vs 119.0 (43.7-213.5), p=0.0249] were also significantly lower than in single chamber mapping group. Conclusion The dual chamber mappings were useful for effective ablation with reducing the radiation exposure.

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Short Title:Dual Chamber Mapping for WPW Syndrome

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Introduction

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Methods

From July 2015 to August 2020, 111 patients underwent ablation of APs. The dual chamber mappings were created in 50 patients [median age 15 (10-54), 32 male(64.0%)], while 61 patients underwent the radiofrequency (RF) ablations with conventional single chamber 3D mappings. The background characteristics and procedure details were compared between the dual chamber mapping group and conventional single chamber mapping group.

Results

The number of RF application [1 (1-3) vs 3 (1-6), p=0.0023], RF time [9.2 (2.0-95.7) vs 95.6 (4.1-248.7), p=0.0023], RF energy [248.4 (58.7-3328.2) vs 2867.6 (134.2-7728.4), p=0.0115] were significantly lower in dual chamber group. Fluoroscopy time [19.9 (14.2-26.1) vs 26.5 (17.7-43.4), p=0.0025], and fluoroscopy dose [52.5 (31.3-146.0) vs 119.0 (43.7-213.5), p=0.0249] were also significantly lower than in single chamber mapping group.

Conclusion

The dual chamber mappings were useful for effective ablation with reducing the radiation exposure.

Keywords: catheter ablation, accessory pathway, ultra-high density mapping, atrioventricular dual-chamber mapping; radiation exposure

Introduction

Catheter ablation has become the indispensable treatment strategy for cardiac arrhythmias[1]. Detailed 3D mapping can identify the reentrant circuit or origin of tachyarrhythmias and has been very important tool for catheter ablation. Rhythmia mapping system (Boston Scientific, Washington, DC), which uses a small basket array with 64-polar mini-electrodes (IntellaMap Orion, Boston Scientific), enables rapid ultra-high-density mapping in a short time[2-4]. The most advantage of this system was little need for additional manual annotation and easily identifies the reentrant circuit[3-4]. Previous reports had demonstrated the usefulness of this system for several complex arrhythmias such as an atrial tachycardia after congenital heart disease surgery, and ventricular tachycardia[5-8]. However, there were only a few reports of investigation about the efficacy of this system in patients with accessory pathway (AP). We previously reported that Rhythmia system can create the atrio-ventricular dual chamber mapping, which would be useful to understand the details of the connection of the AP between atrium and ventricle[9]. We hypothesized that the atrio-ventricular dual chamber map would be useful for the effective radiofrequency (RF) application to the AP patients. The aim of this study was to investigate the utility of Rhythmia system for catheter ablation of AP.

Methods

The study was performed at Saitama Medical University International Medical center. This study protocol was approved by the hospital's institutional review board(20-094).

Study subjects

From July 2015 to August 2020, 128 consecutive patients underwent initial procedure of catheter ablation (CA) for AP guided by an 3D mapping system. The exclusion criteria were case with congenital heart disease, epicardial AP or multiple AP, and the use of cryoablation. Seventeen patients were excluded from this study and the remaining 111 were enrolled into this study.

Mapping and Ablation procedure

Mapping and ablation were performed under the guidance of a CARTO system (Biosense Webster, Diamond Bar, CA), Ensite system (Abbott medical, St. Paul, MN), or Rhythmia system (Boston Scientific, Washington, DC). All ablation procedures were performed under deep sedation using propofol, dexmedetomidine, and pentazocine. The bispectral index (BIS) was monitored and maintained at 40-60. Vascular access was obtained from the right and left femoral vein and, if necessary, from right internal jugular vein. 6Fr duodecapolar, 6Fr decapolar, and 4Fr quadripolar electrode catheters were placed into the coronary sinus, His area, and right ventricle respectively. After venous access was secured, intravenous heparin was used to maintain an activated clotting time more than 300 sec. Electrophysiological study was performed to determine the presence of AP. Bolus infusion of adenosine triphosphate (ATP), extra-stimulus from atrium or ventricle, para-Hisian pacing were underwent to confirm that the antegrade or retrograde conduction was via the AP. When the supraventricular tachycardia (SVT) was induced during control or under an isoproterenol infusion, a standard EPS study was performed to confirm that the SVT was via the AP. In the case of left sided AP, the trans septal approach was performed under the fluoroscopic image and the left side mapping was performed through the trans septal catheter.

The dual chamber map was created by using Rhythmia system and Orion catheter. The potential reference of 3D map was obtained from two different cite in the coronary sinus and the maps were obtained from Orion catheter. Rhythmia system has a specific algorism called "V overlap", which identify the local ventricular potential of mapping catheter. When the V overlap algorism was enabled, the annotation of 3D map focus on the single chamber only (Figure 1A). But the detail connection between atrial and ventricular wasn't clear of this setting. Once the V overlap algorism was disabled, the annotation of 3D map can focus on the different chamber and show a 3D color map of the atrium and ventricle (Figure 1B), which we call the "atrio-ventricular dual chamber map"[9]. Each map was obtained during the ventricular pacing. If there was no retrograde conduction, ventricular map of antegrade conduction was obtained during the atrial pacing (Figure 2). The dual chamber map could be created in the case of type C cases (Figure 3). The 3D map of control group was created by using CARTO system or Ensite system with ablation catheter. The potential reference of 3D map was obtained from a single cite in the coronary sinus and the maps were obtained from ablation catheter. Ablation was performed for the earliest activation site while considering the local potential. Non-irrigation 4mm tip catheter or irrigation 3.5mm tip catheter was used for ablation in order to the operator's decision. The success of ablation was defined as the conduction interruption of APs. After 30 minutes waiting time, the recurrence of APs conduction was confirmed under the isoproterenol infusion and bonus infusion of ATP. The background characteristics and procedure details were compared between the dual chamber mapping group and conventional single chamber mapping group.

Follow-up

All patients were follow-up in out-patient department and the recurrence was as the return of clinical symptoms, documented SVT, or the return of ventricular pre-excitation in 12-leads electrocardiogram.

Statistical analyses

The statistical analyses were performed using JMP® Pro software, version 11.2 (SAS Institute). The continuous variables were compared using a Mann-Whitney test for non-parametric data. The categorical data were compared by a chi-square test. A value of p¡0.05 indicated statistical significance.

Results

RF ablation of single chamber map was performed for 61 patients and dual chamber map was performed for 50 patients. The background characteristics are shown in Table 1. There was no statistical difference

between these two groups.

Procedure details were also shown in table 1. Acute success was obtained in all patients. Cardiac tamponade need pericardiocentesis was observed in 1 patient during the RV catheter insertion (p=0.2672). Arrhythmia recurrence was observed in 2 patients among single chamber map group and 1 patient among dual chamber map group (p=0.6883).

In the dual chamber mapping group, the number of RF application [1 (1-3) vs 3 (1-6), p=0.0023], RF time [9.2 (2.0-95.7) vs 95.6 (4.1-248.7), p=0.0115], RF energy [248.4 (58.7-3328.2) vs 2867.6 (134.2-7728.4), p=0.0115], fluoroscopy time [19.9 (14.2-26.1) vs 26.5 (17.7-43.4), p=0.0025], fluoroscopy dose [52.5 (31.3-146.0) vs 119.0 (43.7-213.5), p=0.0249] were significantly lower than in single chamber mapping group. No significant difference was observed in procedure time between two groups [165.0 (130.0-198.0) vs 180.0 (139.0-212.0), p=0.2733].

Discussion

To the best of our knowledge, this is the first study to examine the Rhythmia system for the ablation of APs. The major findings in our study were as follows; 1) The dual chamber map was useful to the effective ablation with a few RF application. 2) The use of Rhythmia system could reduce the fluoroscopy time and dose.

Dual Chamber map for effective ablation

CARTO system and Ensite system could annotate only atrial or ventricular potentials and are not able to distinguish between atrial and ventricular potentials during the same maps. However, the Rhythmia system has an intelligent annotation technology and annotates the largest bipolar potential, which enables distinguishing the atrial and ventricular potentials all at once and can construct an atrioventricular dual-chamber map without a manual reannotation[9]. Accessory pathways are located at the atrio-ventricular (AV) annulus and the understanding of the anatomical position of AV annulus is important for ablation of APs. The dual chamber map enables us to understand this important factor before the application of RF energy. Furthermore, the continuous activation pattern of APs from one chamber to another chamber was also useful to the understanding of the site of APs. As a result, the number of radiofrequency applications, radiofrequency time, and energy in the dual chamber map group were significantly lower than the of the single chamber map group.

Reduction of fluoroscopy time and dose

The success rate of ablation of AP was more than 90% and the incidence of complication was relatively low[10-11]. Therefore, catheter ablation of APs was standard therapeutic strategy for symptomatic AP patients[1,12]. However, the ablation needs the use of fluoroscopy and are associated with the radiation exposure for patients and medical staff. The long term risk of cancer from this medical radiation exposure was reported to be linear relation without no threshold. The higher dose of radiation exposure increases the risk of cancer. “ALARA- as low as reasonably achievable” is the principle for fluoroscopically guided invasive cardiovascular procedure[13]. The use of 3D mapping can reduce the irradiation time and its dose[14-17]. Furthermore, CARTO UNIVU system, which integrate the fluoroscopic images with the 3D map, can also reduce the radiation exposure for ablation of APs[14]. Our study also revealed that the dual chamber map can reduce the radiation exposure, compared with the single chamber map. With the single chamber map, fluoroscopic image is needed before the energy application to confirm the position of AV annulus. However, the dual chamber map can be useful to the detail connection of APs between atrium and ventricle. Once the map was created, the radiation wasn't necessarily needed before the energy application. As a result, the radiation exposure was lower in the dual chamber map group.

SVT with APs are often found in young patients and the influence of radiation exposure was hazardous especially in younger patients. The safety and accuracy of the Rhythmia system for pediatric patients was previously unknown, but we reported that the Rhythmia system was safe and accurate in pediatric

population. Our study included 28 patients whose age were less than twenty and the minimum age was 3 years-old. The dual chamber map would be useful for patients of various generations.

The radiation time and dose in both groups were relatively higher than that of the previous study[14,15]. The fluoroscopic time in the study of CARTO UNIVU was only 0.1min[14]. The securing of vascular access, the insertion of EP catheter, and the trans septal puncture in our study was performed under the fluoroscopic guide. This could be result in the higher fluoroscopic time and dose than that of the previous study.

Study limitations

Our study had several limitations. Firstly, this study was analyzed retrospectively, and a single-center cohort. So further prospective randomized trials might be needed to validate our results. Secondary, the mapping of single chamber map was created by using ablation catheter. The multielectrode catheter wasn't used to create the single chamber map.

Conclusions

The dual chamber mapping was useful for effective ablation with reducing the radiation exposure. Mapping of atrium and ventricle all at once was useful for the understanding of detail connection of APs. Shorter radiation exposure would be useful for patients and medical stuffs.

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Author's contributions

HM, RK and NS, study conception and design; DK, SM, TN, KT and YI, data collection and data analysis; SI, SN, TM and TK, manuscript revision; KM, study supervision

Disclosure

The authors have no conflicts of interest to disclose.

Data Availability Statement

The data underlying this article cannot be shared publicly due to our IRB policy. However, the data will be shared on reasonable request to the corresponding author.

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Figure Legend

Figure 1. Creation of atrio-ventricular dual chamber map

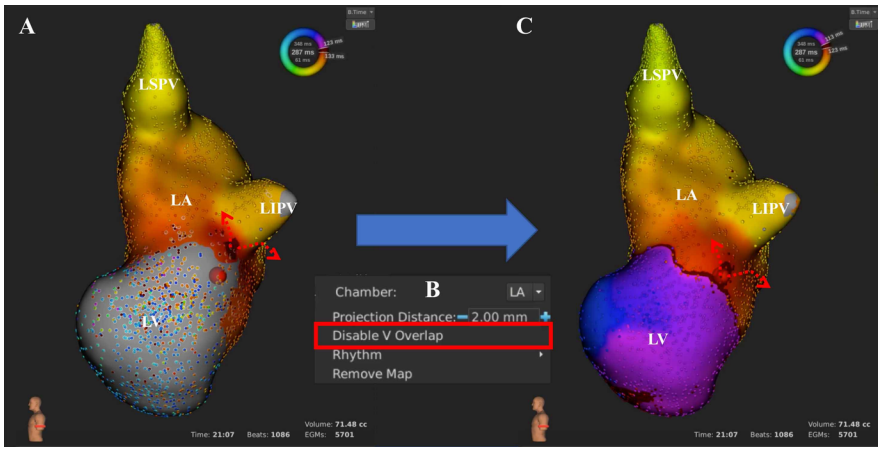
When the V overlap algorism was enabled, the annotation of 3D map focus on the single chamber only (A). But the detailed connection between atrial and ventricular was not clear and the earliest activation site was away from the success site (red tag). Once the V overlap algorism was disabled (B), the annotation of 3D map can focus on the different chamber and show a 3D color map of two chamber. The atrial activation was spread from the success site (C).

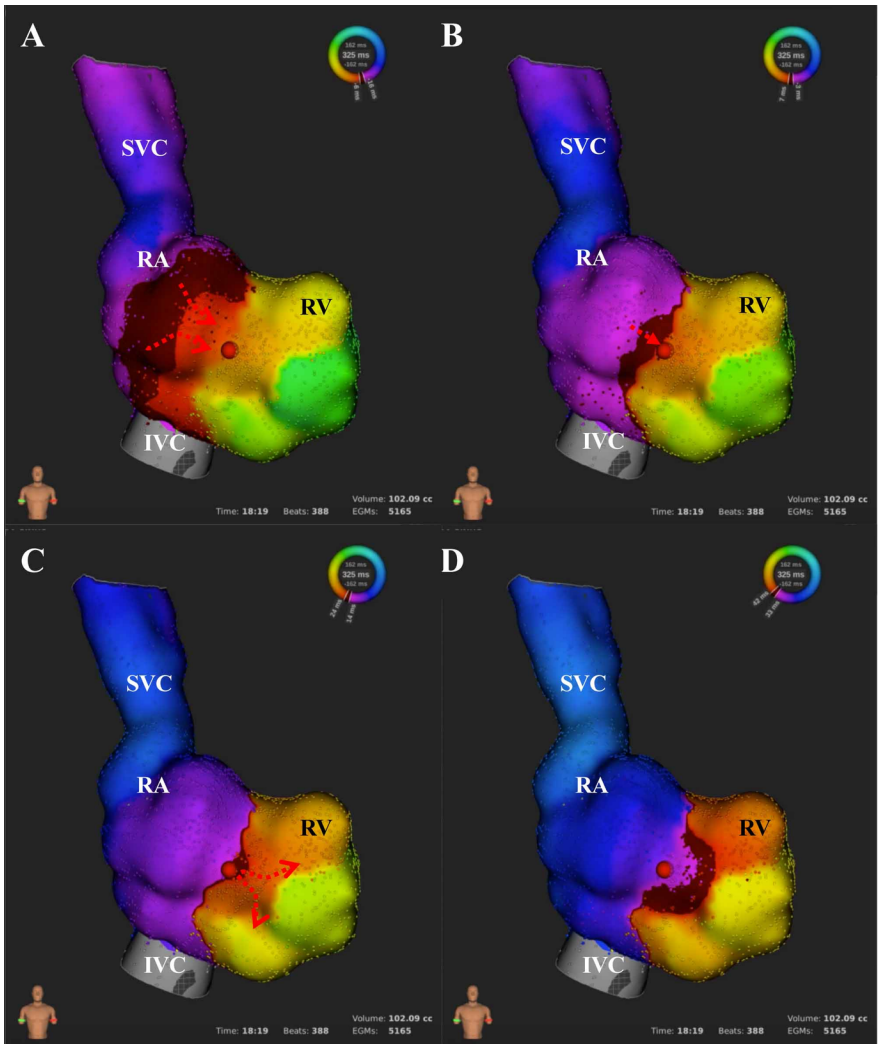
Figure 2. Representative figure of dual chamber map of right sided accessory pathway with antegrade conduction

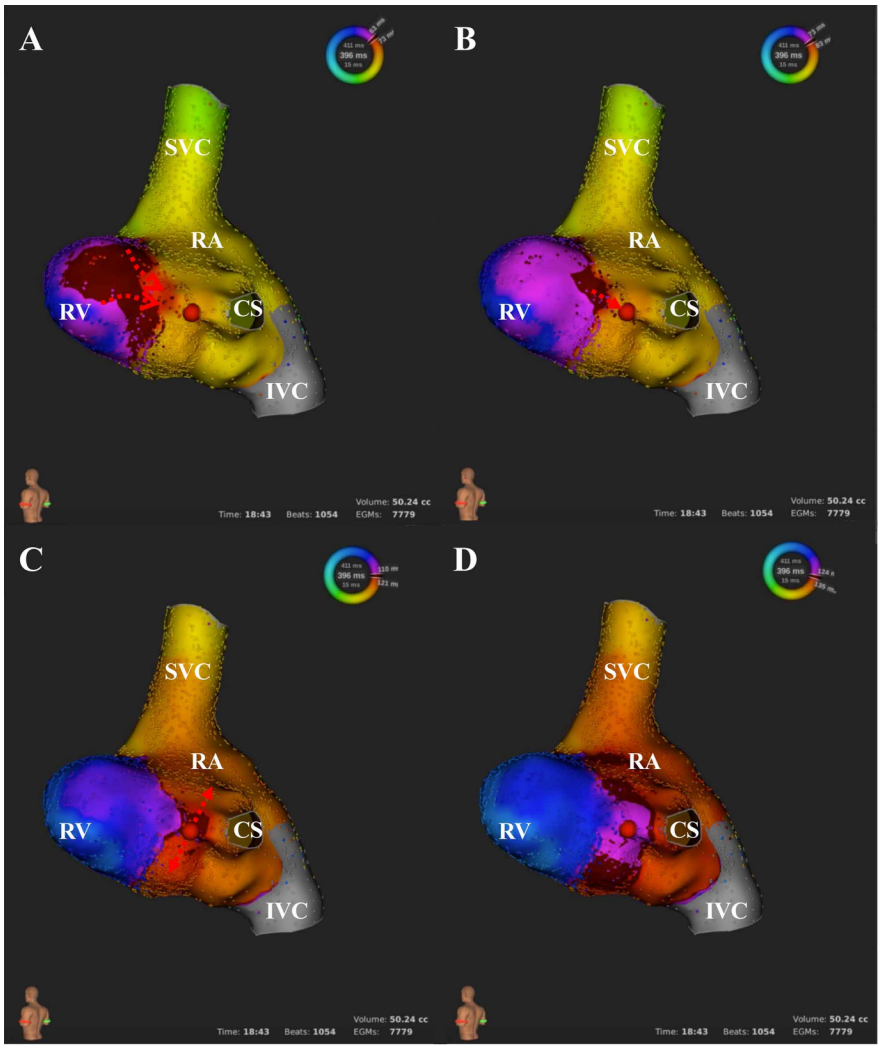
The atrial activation was gathered to the atrio-ventricular annulus and spread to the ventricle. Antegrade conduction was interrupted soon after the energy delivery at the red tag site.

Figure 3. Representative figure of dual chamber map of septal accessory pathway with retrograde conduction

The ventricular activation was gathered to the atrio-ventricular annulus and spread to the atrium. Retrograde conduction was interrupted immediately after the energy delivery at the red tag site.







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