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Effects of a Combination of Fixed and Steerable Sheaths Applied for Catheter Ablation of Left Anterolateral Papillary Muscle-Related Arrhythmias

Lei S[1#], Wang R[1], Wang N[2], Gao L[1] and Cheng L[2]**

[1]Department of Cardiology, The First Affiliated Hospital of Chongqing Medical University, China

[2]Department of Cardiology, Songshan General Hospital, China

[#]The first author

Abstract

Background: Left anterolateral papillary muscle-related arrhythmias are sometimes difficult to ablate.

Aim: To investigate the effects of a combination of fixed and steerable sheaths in catheter ablation for left anterolateral papillary muscle-related arrhythmias.

Methods: Twenty-nine patients were included and divided into a combined fixed and steerable (Vizigo) sheath group (n=12), a fixed (Swartz) sheath-only group (n=13), and a steerable (Vizigo) sheath only group (n=4). Ablation was performed under intracardiac echocardiography in each patient. The procedural time and success rate were analyzed.

Results: In the Vizigo-sheath-only group, rough mapping was very difficult when using the Vizigo sheath. Four patients in these groups were switched to the combined group. Six patients in the Swartz-sheath-only group and none in the combined-sheath group experienced clinical arrhythmia recurrence. The recurrence-free survival rate was greater in the combined-sheath group (100.0% *vs*. 53.8%, P=0.005). The total procedural time was 122.9 ± 7.0 min for patients in the combined sheath group and 131.0 ± 9.0 min for patients in the Swartz group. There was a significant difference in procedure time between the combined-sheath group and the Swartz-sheath-only group (122.9 ± 7.0 *vs*. 131.0 ± 9.0, P=0.02).

Conclusion: A combination of fixed and steerable sheaths is useful for the ablation of left anterolateral papillary muscle-related arrhythmias.

Keywords: Ablation; Left anterolateral papillary muscle; Steerable sheath; Ventricular arrhythmias

Abbreviations

ECG: Electrocardiogram; ICE: Intracardiac Echocardiography; LAP: Left Anterolateral Papillary muscle; LV: Left Ventricle/Ventricular; Ms: Millisecond; VA: Ventricular Arrhythmias

Introduction

Radiofrequency catheter ablation has been proposed as an effective approach for treating Left Anterolateral Papillary muscle (LAP) -related arrhythmias [1-4]. However, it can be challenging to perform because of the anatomic complexities of the papillary muscles [5-7]. Reports of LAP-related arrhythmias are limited. Imaging studies have shown that the papillary muscles are mobile intracavitary structures, more like a cypress tree, with a series of roots or tentacles that originate from the Left Ventricular (LV) wall [8,9]. The transseptal approach is suggested for ablation of LAP-related ventricular arrhythmias [10]. A new type of bidirectional steerable sheath (Vizigo sheath; Biosense Webster, Inc., CA, USA) that can be visualized on a three-dimensional system has already been employed in clinical treatment [11,12]. We assume that using this steerable sheath alongside a fixed sheath may improve ablation stability and enable easy spatial manipulation of the catheter transeptally when ablating LAP-related arrhythmias. This study aimed to compare the effectiveness and safety of the combined fixed and steerable sheath to a fixed sheath (Swartz sheath; St. Jude Inc., St. Paul, MN, USA) for catheter ablation of LAP-related arrhythmias.

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***Correspondence:**

Lingyun Gao, Department of Cardiology, The First Affiliated Hospital of Chongqing Medical University, Yuzhong, Chongqing, 400016, China, Tel: +86 15215168981; Li Cheng, Department of Cardiology, Songshan General Hospital, 69 Xingguang Street, Chongqing, 401120, China, Tel: +86 13983482913;

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Method

Study design and participant characteristics

Twenty-nine patients (18 years or older) with LAP-related ventricular arrhythmias confirmed by Intracardiac Echocardiography (ICE) who underwent catheter ablation were included in this study between January 2020 and January 2023 at the First Affiliated Hospital of Chongqing Medical University and Songshan General Hospital. Twenty-nine patients were included and divided into the combined fixed and steerable (Vizigo) sheath group (n=12), the fixed (Swartz) sheath only group (n=13), and the steerable (Vizigo) sheath-only group (n=4). The baseline data, such as age, sex, body mass index, cardiovascular history, left atrial diameter, Left Ventricular (LV) diameter, LV ejection fraction, and valve regurgitation, were reviewed.

Preoperative preparation

This study conformed to the principles of the Helsinki Declaration and was approved by the ethics committee of Chongqing Medical University. Written informed consent was obtained from all participants after the details of the study were explained. Twenty-four Holter ECGs and standard 12-lead ECGs were recorded before the ablation procedure.

Electrophysiological study and catheter ablation

Venous access was obtained from the femoral vein. A Decapolar catheter was positioned in the coronary sinus. Heparin was administered to maintain an activated clotting time of 300 sec to 350 sec. Intracardiac echocardiographic guidance was used in all patients. A Navistar SMARTTOUCH catheter (Johnson & Johnson) was applied to the left ventricle for activation mapping during arrhythmia. All patients underwent surgery *via* the transseptal approach.

In the combined group, activity mapping was first performed for each patient with a Swartz sheath. Then, Vizigo sheaths were used for further mapping and ablation. In the Vizigo sheath-only group, rough mapping was very difficult in all 4 patients because the diameter of the Vizigo sheath was greater than that of the normal Swartz sheath, and it was difficult to map the whole ventricle to locate the source of tachycardia. In the Vizigo-only group, the Vizigo sheath was switched to the Swartz sheath to map the tachycardia and then switched back to the Vizigo sheath to map and ablate in the local area. Therefore, the 4 patients initially in the Vizigo-only group were switched to the combined group. Detailed activation mapping was used in all patients to define the ventricular arrhythmia site of origin as follows: The catheter was manipulated under ICE and three-dimensional electroanatomic map guidance to sample all heads of the LAP to identify the earliest ventricular activation sites. Lesions of ablation included sites with ventricular activation earlier than –30 milliseconds (ms) pre-QRS and a QS pattern in the local unipolar recording. Ablation was performed at the earliest activity sites. Sometimes pacing mapping was used to confirm the target. During ablation, the power was set to 30 W and then increased every 5 sec to 10 sec to a maximum of 50 W to achieve an impedance drop of ≥ 10 Ω. Depending on the arrhythmia response and catheter stability, the lesion duration ranged from 60 sec to 90 sec. We are more concerned about catheter stability than contact force because a greater force easily causes catheter displacement [10,13].

The procedural time and success rate were analyzed. Success was defined as complete suppression of targeted Ventricular Arrhythmias (VAs) ≥ 30 min post-ablation, and clinical success was defined as a ≥ 80% reduction in VA burden at outpatient follow-up.

Success definition and follow-up

Acute success was defined as the elimination of targeted clinical VAs for at least 30 min after the completion of ablation. Following the ablation procedure, the subjects were monitored on telemetry overnight. Patients were then evaluated in outpatient visits at 3- and 6-month intervals.

Holter (24-h or 48-h duration) and/or mobile cardiac outpatient telemetry monitoring was performed at 3- and 6-month intervals if there were no symptoms. Electrocardiography (ECG) or Holter monitoring data were obtained and reviewed when patients experienced symptoms.

Statistical analysis

Continuous variables are reported as the mean ± standard deviation. Qualitative findings are presented as numbers and percentages. The Shapiro–Wilk test was used to determine if there was a normal distribution of quantitative data. The Levene test was performed to verify the relative homogeneity of variance. T-tests and Mann–Whitney tests were used for statistical comparisons. Qualitative variables were compared using the χ^2 test. A P value lower than 0.05 was considered significant. Analyses were performed using SPSS software (version 16).

Results

Baseline clinical characteristics

The mean age was 52 ± 13 years, and 68% (n=17) of the patients in this study were male. All patients manifested premature ventricular complexes; among them, 1 patient also presented with non-sustained VA. There was no structural heart disease. Ten patients had hypertension, and two had diabetes. LV ejection fraction was 50.0 ± 10.5%. There was no significant difference in age, sex, body mass index, hypertension incidence, or diabetes mellitus incidence between the Vizigo group and the Swartz group. The echocardiography results revealed no significant differences in the left atrial diameter, LVD, LV ejection fraction, or valvular regurgitation between the groups. The clinical baseline characteristics are shown in Table 1.

Electrocardiographic characteristics

Baseline ECG showed sinus rhythm in all patients. The mean QT and QTc intervals were 411.7 ± 35.1 and 410.7 ± 28.8 ms, respectively. ST-T wave abnormalities were observed in 5 patients.

All the mapped premature ventricular contractions exhibited a right bundle branch block pattern with a mean QRS duration of 140 ± 14 ms. All the patients had either an inferiorly directed axis (n=15) or an inferior lead (n=14), with a negative QRS in lead II and a positive QRS in lead III. The precordial transition occurred at lead V3 in 8 patients, V4 in 9 patients, V5 in 4 patients, and V6 in 4 patients. A q wave in the lateral leads was present in seven patients (Figure 1).

Procedural data

The earliest sites were located at LAP bodies in 12/16 (66%) patients in the combined group and 7/13 (53%) patients in the Swartz group. The earliest sites were located at the base of the LAP in 8/16 (33%) patients in the combined group and 6/13 (46%) patients in the Swartz group. The LAP tip exhibited no earliest sites.

The total procedural time was 122.9 ± 7.0 min for patients in the combined group and 131.0 ± 9.0 min for patients in the Swartz group. There was no significant difference in procedure time between the

Figure 1: A case of left anterolateral papillary muscle-related arrhythmia ablation in the combined group.
An electrocardiogram revealed a positive QRS complex in the inferior leads. Ablation with a Swartz sheath temporarily suppressed premature ventricular contractions but reoccurred after the ablation stopped. After mapping with a Swartz sheath, further ablation with a Vizigo sheath terminated the premature ventricular contractions and premature ventricular contractions did not reoccur afterward.

Table 1: The baseline data in each group.

	Overall (N=29)	combined group	Swartz group	P value
Age, years	53.2 ± 14.6	57.1 ± 13.0	49.6 ± 15.5	0.20
Male	15	9	6	0.10
HTN	10	5	5	0.87
DM	1	1	0	-
CHD	6	4	2	0.40
LA	33.0 ± 3.2	32.5 ± 4.0	33.4 ± 2.2	0.50
LVd	46.4 ± 3.9	45.7 ± 4.1	47.1 ± 3.7	0.38
EF	65.3 ± 4.8	64.7 ± 4.7	65.8 ± 5.1	0.58

HTN: Hypertension; DM: Diabetes Mellitus; CHD: Coronary Heart Disease; LA: Left Atrium; LVd: Left Ventricular diameter; EF: Left Ventricular Ejection Fraction

combined group and the Swartz group (122.9 ± 7.0 *vs.* 131.0 ± 9.0, P=0.02).

Complications

None of the patients experienced complications during the operation.

Acute and long-term (clinical) outcomes

In the Swartz group, VA reoccurred after the procedure in 3 patients. There was no VA reoccurrence in the combined group.

After 6 months of follow-up, 3 patients in the Swartz group had VA, but none had VA in the combined group. The recurrence-free survival rate was greater in the combined group (100.0% *vs.* 53.8%, P=0.005).

Discussion

This study demonstrated that compared to the use of a Swartz sheath, the use of a Vizigo sheath with a Swartz sheath for catheter ablation of LAP-related arrhythmias could significantly increase the success rate.

Interestingly, the Vizigo sheath is very helpful for stabilizing the catheter and mapping in a small area. However, it is difficult to roughly map the whole ventricle or small atria with a Vizigo sheath.

Indeed, because the diameter of the Vizigo sheath is larger than that of the normal Swartz sheath, it is difficult to map the whole ventricle to locate the source of tachycardia. In our study, all patients who used the Vizigo sheath for mapping were switched to the combined group.

The reason why the total procedural time did not decrease in the combined group was that using the Vizigo sheath for rough mapping was difficult and required too much time in the Vizigo sheath-only group, and all Vizigo-only group patients were moved to the combined group.

In our study, a limited effect was observed when the procedure was performed by traditional ablation using a fixed curve sheath. These results are different from those of Aung N. Lin, who reported that acute success was achieved in 95% of patients, and clinical success was achieved in 82% of patients. Complications occurred in 5 patients (3.6%) in the study [10]. Our limited effect may be caused by cautious ablation and limited experience. However, when the Vizigo sheath combined with a fixed curve sheath was used, the success rate significantly increased.

Another previous study showed that the acute success rate was 83%, but the rate decreased to 48% in the following year. A higher acute success rate indicates that the real source of VA was found, while a lower follow-up success rate demonstrates that there may be catheter instability [14]. Another study [4] revealed very few recurrent arrhythmias following a repeat ablation procedure. This may also account for the importance of catheter stability during ablation. Our study revealed an increased success rate during follow-up, which may be caused by the use of a Vizigo sheath combined with a Swartz sheath.

Rivera et al. [15] reported that the acute success rate was 100% for cryoenergy catheter ablation and 78% for RF. Catheter stability was achieved in all patients (100%) treated with cryoenergy catheter ablation and in only 2 (25%) patients treated with RF. This also indicates the importance of stability during PMVA ablation.

The transseptal approach was favored for LAP-related VA in other studies [16]. We also found that the transseptal approach was more effective than the retrograde approach in this study. The catheter is not flexible in the left ventricle during the retrograde approach, but it can move freely during the transseptal approach, which is important for identifying the earliest sites of the VA.

When using the Swartz sheath, it was usually faster to confirm that the rough origin was the LAP. However, it was difficult to perform further fine mapping. The diameter of the Vizigo sheath is usually greater than that of the Swartz sheath, which limits the flexibility of the catheter, but the Vizigo sheath can improve catheter location stability and ease meticulous mapping. We found that combining the Swartz sheath and Vizigo sheath was very effective for LAP-related ARF ablation.

Fitzpatrick et al. [17] demonstrated that the use of a visualizable steerable sheath for catheter ablation of atrial fibrillation significantly reduced radiation exposure compared with the use of a non-visualizable steerable sheath. They found that the mapping time was longer with the use of a visualizable sheath, but the overall procedure time did not increase. The fluoroscopy time was also decreased by the use of a Vizigo sheath in our study, indicating that the use of a visualizable steerable sheath also improved the efficiency of ventricular arrhythmia ablation. In addition, Vizigo use in our study also decreased the total procedure time.

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