Evaluation of superior vena cava stenosis after superior vena cava isolation in patients with atrial fibrillation.

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Abstract

Introduction: The isolation of superior vena cava (SVCI) and pulmonary vein isolation (PVI) improve the success rate of atrial fibrillation (AF) ablation. Limited information is available on the quantitative assessment of the narrowing of SVC after ablation. Methods: Ninety-one AF patients with SVC potentials were enrolled in this study. After PVI, SVCI was performed circumferentially at the level of the lower border of the right pulmonary artery. Radiofrequency (RF) pulses were delivered on a point-by-point basis for 30s at each point with an irrigated catheter in a temperature-controlled mode with the maximum temperature set at 42 and the maximum power at 25W. Follow up contrast-enhanced computed tomography was performed at four months after the ablation procedure. SVC narrowing was followed up in time (mean ± standard deviation = 20 ± 4.2 months). Results: All SVCIs were successfully achieved without severe complications. The pre-ablation SVC dimension at the level of the isolation line was 2.50 ± 0.94 cm2, and the post-ablation SVC dimension was 2.19 ± 0.82 cm2 ($p = 0.016$). Severe stenosis (reductions of SVC dimension > 75%) was not observed in this study. Moreover, the relationship between the SVC narrowing and the RF application time was not significant in this study. In the eight SVC cases with SVC narrowing, the mean SVC area recovered as a function time from 1.56 ± 0.42 cm2 to 1.80 ± 0.57cm2. Conclusion: The SVCI caused minor reductions in the SVC dimensions, but did not cause severe stenosis with life-threatening symptoms.

Keywords

Superior vena cava isolation, Superior vena cava stenosis, Atrial fibrillation, Catheter ablation, Pulmonary vein isolation

Introduction

Episodes of atrial fibrillation (AF) are mainly initiated by triggers from the pulmonary veins.[1] The superior vena cava (SVC) has been identified as a second major substrate of non-PV foci that accounts for 5–10% of all AF causes.[2,3] The electrical disconnection of the SVC from the right atrium is feasible, and SVC isolation (SVCI) in addition to PV isolation (PVI) improve the outcomes of AF ablations.[4,5] Despite its efficacy, empirical SVCI is not a common procedure because some complications may develop after the ablation, such as phrenic nerve paralysis, sinus node injury, and SVC stenosis.

Previous research studies demonstrated no evidence of SVC stenosis following SVCI at three months after the procedure.[6]However, only a few published reports have conducted quantitative assessments of the SVC area. In this study, we evaluated the SVC area four months after the ablation, and in subsequent followed periods.

Methods

Study population

Ninety-four paroxysmal AF (PAF) patients (68 male and 26 female, mean age ± standard deviation = 66 ± 10 years) with SVC potentials who underwent AF ablations were included in this study. PAF was defined as AF with duration < 7 days. Those who underwent cardiac implantable electrophysiological device implantation were excluded from this study. A contrast-enhanced computed tomography (CT) scan (Revolution CT. GE Healthcare, Chicago, Illinois, USA) was conducted prior to the ablation to estimate the intracardiac thrombus and SVC area. Antiarrhythmic drugs were discontinued for at least five half-lives prior to the ablation. This study was executed according to the protocol that was approved by the Ethnic committee at the Kimitsu Central Hospital.

SVC isolation

Empirical SVC isolations were performed in the first AF ablation session. The SVC potentials were recorded by a variable 20 polar, circular mapping catheter (7F Inquiry Optima^{TM} PLUS Catheter; Abbott, St Paul, Minnesota, USA) at the level of the lower border of the right pulmonary artery after SVC venography. The isolation line was set at the level of the lower border of the right pulmonary artery to avoid sinus node injury (Figure 1A). Phrenic nerve (PN) capture sites were confirmed following the execution of 5 V pacing protocols. The SVC was ablated on a point-by-point manner with an irrigated ablation catheter (Flexability^{TM}; Abbott, St Paul, Minnesota, USA). Radiofrequency (RF) pulses (25 W) were applied for 30 s, and they were delivered circumferentially with the exceptions of the PN (Figure1B). If the SVC potential remained after the circumferential isolation, additional PN capture site applications were delivered for 20 s at 20 W, while the diaphragmatic movement was evaluated with fluoroscopy. The endpoint of SVC isolation was bidirectional block between the SVC and the atrium. Dormant SVC conduction was induced following the administration of adenosine triphosphate (20 mg) in the cases at which SVC automaticity was noticeable during the ablation process.

Evaluation of the SVC area

The patients were followed up periodically in an outpatient clinic, and were evaluated for episodes of AF recurrence based on regular 12-lead electrocardiograms at 1, 4, 7, 10 and 13 months after the ablation, and an event recordings (Spiderflash-T^{TM}; Japan Lifeline Co., Ltd. Tokyo, Japan) at 3, 6, and 12 months after the ablation. The SVC area was evaluated four months after the ablation via a contrast-enhanced CT scan (Figure 2A). The SVC area was measured by tracing at the isolation line with a commercially available software program (Ziostation2; Ziosoft, Inc., Tokyo, Japan). Cases with dimensional reduction > 50% were followed up and re-evaluated.

Statistical analyses

Continuous variables were expressed as mean ± standard deviations. Data were analyzed with one-way analysis of variance or Student's t-tests. A P value < 0.05 was considered statistically significant.

Results

Patient characteristics

Table 1 shows the patient characteristics at baseline in this study. The patients consisted of 68 males and 26 females (age range from 42 to 85 years, with a mean of 66 years). All SVC isolations were achieved successfully without any acute complications. Although 33% of the all patients were needed an additional application for the PN capture site, PN paralysis (PNP) was not observed after the procedure. At the one-month followup, two patients developed asymptomatic PNP, but both got recovered four months after the ablation procedure. Ectopic foci from SVC were observed in 13% of the patients.

SVC area

Figure 2B shows a comparison of the SVC area before and after the ablation process. The mean SVC area at baseline was 2.50 ± 0.94 cm^2. By contrast, the SVC area after the ablation was reduced to 2.19 ± 0.82

cm^2. Trivial (0–25%), mild (25–50%), moderate (50–75%) stenoses were observed in 73 (78%), 13 (14%), and 5 (5%) patients, respectively. No severe stenosis (dimensional reduction >75%) was observed in this study. The relevant application times are plotted in Figure 3. No significant differences were noted among the three groups, and the degree of SVC narrowing was not found to be significantly correlated with the application time.

Eight patients associated with 18 mild and moderate narrowing cases (1.56 ± 0.42 cm^2) were followed further at 20 ± 4.2 months after the ablation process, and the SVC area were estimated again. The mean SVC area shown in Figure 4 was 1.80 ± 0.57 cm^2. This is slightly larger compared to the value recorded four months after the ablation process. SVC narrowing did not progress with the exception of two cases that did not develop symptomatic severe stenosis.

Discussion

Main Findings

In the present study, we evaluated the incidence of SVC stenosis after SVC isolation. A contrast-enhanced CT scan obtained four months after the ablation yielded a 14% reduction in the SVC dimensions without any concomitant life-threatening symptom.

The quantitative assessment of the SVC area after the SVC isolation has not been investigated adequately until now. Arruda et al. reported that the SVC area changed from 2.83 ± 0.63 cm^2 to 2.61 ± 0.76 cm^2 following the SVC isolation in 68 AF patients.[7] In that research, high-output pacing was performed (30 mA) before RF pulses were delivered at the posterolateral aspect of SVC to evaluate the diaphragmatic stimulation. The SVC isolation was aborted to avoid PNP in the case of diaphragmatic stimulation.[6] Correspondingly, complete SVC isolation was achieved in 85% of the patients. In our cases, RF pulses (20 s, 20 W) were delivered circumferentially even at the phrenic nerve capture sites in the cases at which the SVC potential was maintained after the ablation process. All SVC isolation procedure were completed successfully without any acute complications.

Miyazaki et al.[8] demonstrated the prevalence of the SVC reconnection after the first SVC isolation was observed in 74% of the studied patients. Moreover, Arruda et al. reported a 12% incidence of SVC triggers in a cohort of the 190 AF patients they studied.[7] Based on these research studies, complete and durable SVC isolation is considered to improve the outcome of AF ablation even if the recent meta-analysis noted the controversy related to the additional benefits of empirical SVC isolation.[9]

In the previous studies, the SVC areas were evaluated only at three months after the ablation process. Therefore, SVC narrowing data after this timeframe is limited. In this study, in the six out of the eight narrowing cases, the SVC narrowing did not progress. SVC stenosis did not develop in any of the studied cases and there were no life-threatening symptoms. This means that the SVC stenosis which developed in subsequent time intervals did not seem to be of significant concern.

Limitations

Our study is limited by the lack of randomization. The main concern is that the SVC area is variable because it depends on the intravascular blood volume, even if the patients were prohibited to have any oral intake during the 2 h interval before and after the examination. In addition, not all the patients were not followed up with CT scans to avoid excess radiation exposure.

Conclusions

SVC isolation causes minor decreases of the SVC area. However, this procedure does not cause life-threatening symptoms. SVC stenosis after SVC isolation is not a significant concern.

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Tables

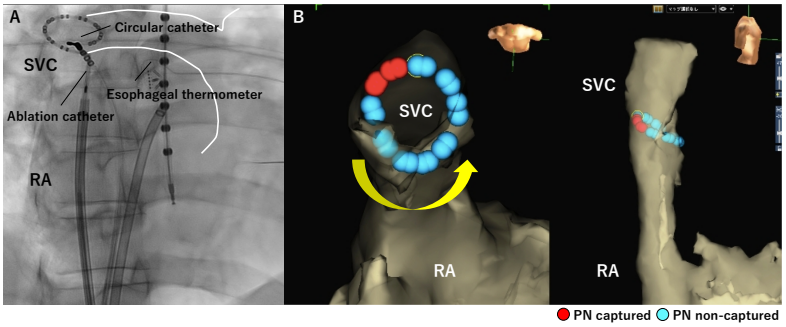
Figure legends

Figure1. Panel A shows a circular mapping catheter placed at the SVC. The white line indicates the right pulmonary artery, while the isolation line is set at its lower border. Panel B shows the 3D anatomical maps of the SVC seen from the superior and the right anterior oblique views. The red tags indicate the sites at which the phrenic nerve are captured following the application of 5 V pacing pulses. Initial RF applications were delivered circumferentially at the blue tag locations.(yellow arrow).

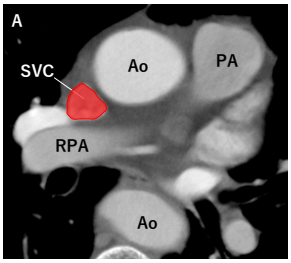
Figure 2. Representative case of the contrast-enhanced CT scan is shown in the panel A. The red area is the cross-section of the SVC. This area is measured by tracing its boundary with a commercial software program at the level of the lower border of the RPA. Each dot shown in panel B indicates the SVC area at baseline and four months after the ablation. The mean SVC area significantly decreased from 2.50 $\pm$ 0.94 cm^2 to 2.19 $\pm$ 0.82 cm^2 ($p = 0.016$).

Figure 3. Mean applications time of trivial, mild, and moderate stenosis groups are 203 $\pm$ 53, 210 $\pm$ 52, and 216 $\pm$ 144 s, respectively. There are no significant differences among the three groups.

Figure 4. Initial SVC area of mild and moderate stenosis groups is 2.70 $\pm$0.75 cm^2. This value reduces to 1.56 $\pm$ 0.42 cm^2 at four months after the ablation, but recovers slightly to 1.80 $\pm$ 0.57 cm^2 at the second followup.



SVC = superior vena cava; 3D = three-dimensional; RA = right atrium; PN = phrenic nerve; RF = radiofrequency



Ao = aorta; PA = pulmonary artery; RPA = right PA