JACC: CASE REPORTS VOL. 2, NO. 11, 2020

MINI-FOCUS ISSUE: ARRHYTHMIAS AND EP

INTERMEDIATE

CASE REPORT: CLINICAL CASE

Coronary Arterial Vasospasm

A Rare Complication of Vein of Marshall Ethanol Infusion for Atrial Fibrillation

Shingo Maeda, MD,[a] Kaoru Okishige, MD,[b] Yasuhide Tsuda, MD,[a] Ryo Yonai, MD,[c] Tomoyuki Kawashima, MD,[c] Jackson J. Liang, DO,[d] Ruben Casado Arroyo, MD,[e] Mihoko Kawabata, MD,[a] Hirotsugu Atarashi, MD,[f] Kenzo Hirao, MD[a]

ABSTRACT

A 75-year-old man was admitted for repeat ablation of atrial fibrillation. At 30 min after infusion of 3.5 ml of ethanol into the vein of Marshall, inferior ST-segment elevation with coronary arterial vasospasm was observed. This is the first report of coronary vasospasm after chemical ablation of the vein of Marshall. (**Level of Difficulty: Intermediate.**)

(J Am Coll Cardiol Case Rep 2020;2:1766–70) © 2020 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 75-year-old man with symptomatic drug-refractory atrial fibrillation (AF) and with recurrent AF after previous AF ablation was admitted for repeat catheter ablation.

PAST MEDICAL HISTORY

Other than AF, the patient had no cardiac history and no coronary artery disease risk factors. He denied symptoms concerning for angina. The patient had no family history of a cardiac disorder or sudden death.

INVESTIGATIONS

The patient was brought into the electrophysiology laboratory for repeat ablation. All 4 pulmonary veins

LEARNING OBJECTIVES

- Coronary vasospasm is a rare potential complication of ethanol ablation of the VOM. Because it can take time for completion of lesion formation after ethanol infusion, it may be prudent to monitor patients for 30 to 45 min after ethanol ablation.
- ST-segments should be monitored closely on 12-lead ECG during and after ethanol ablation.
- Limiting the dose of the ethanol infusion (1.0 to 1.5 ml over 90 to 120 s) could help prevent this complication.
- Pre-procedure computed tomography and electroanatomic mapping can delineate the relationship of the VOM with the coronary arteries and other collateral structures.

From the [a]Arrhythmia Advanced Therapy Center, AOI Universal Hospital, Kanagawa, Japan; [b]Yokohama Minato Heart Clinic, Yokohama, Japan; [c]Cardiovascular Therapy Center, AOI Universal Hospital, Kawasaki, Japan; [d]Department of Cardiac Electrophysiology, University of Michigan, Ann Arbor, Michigan; [e]Department of Cardiology, Hopital Erasme, Université Libre de Bruxelles, Brussels, Belgium; and the [f]Department of Internal Medicine, Minami-Hachioji Hospital, Tokyo, Japan. The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the *JACC: Case Reports* author instructions page.

Manuscript received May 11, 2020; revised manuscript received June 19, 2020, accepted June 30, 2020.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2020.06.046

(PVs) were chronically isolated; during isoproterenol infusion, recurrent premature atrial contractions were seen that occasionally triggered AF. These premature atrial contractions were noted to be earliest at the distal coronary sinus (CS). Detailed activation mapping identified the site of origin of this premature atrial contraction to be from the left atrial (LA) endocardial aspect of the vein of Marshall (VOM). Therefore, VOM ethanol ablation was performed to target non-PV triggers. To delineate the anatomy of the CS, occlusive balloon venography of the CS was performed. The VOM was visualized in the right anterior oblique projection. To cannulate the VOM, both outer (CPS DirectTM 47 cm, Abbott, St. Paul, Minnesota) and inner (CPS AIMTM 59 cm, Abbott) CS delivery sheaths were used from the right internal jugular vein. After VOM venography, an angioplasty wire (ATHLETE Premium, Japan Lifeline, Tokyo, Japan) and an angioplasty balloon (15-mm length, 1.5-mm diameter, Emerge PTCA Dilatation Catheter, Boston Scientific, Marlborough, Massachusetts) were advanced into the VOM as distally as possible. In this case, the length of the VOM was very short (11 mm), and a total of 3.5 ml of 98% ethanol was infused slowly over 90 s from the VOM ostium during balloon dilation (**Figure 1**, Video 1). Electroanatomic bipolar voltage mapping confirmed a localized low-voltage zone (<0.1 mV) on the endocardial left atrium across from the VOM, and the procedure was concluded without any supplemental ablation in the LA endocardium opposite the area targeted by ethanol injection. After removal of all venous sheaths (30 min after the ethanol infusion), the 12-lead electrocardiogram (ECG) demonstrated ST-segment elevation in the inferior leads with unstable hemodynamic values (**Figures 2A and 2B**).

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of ST-segment elevation in the inferior leads during AF ablation includes air embolism, LA embolism to the right coronary artery (RCA), coronary vasospasm, and acute pericarditis.

INVESTIGATIONS

Arterial access was obtained, and urgent coronary angiography was performed, which revealed focal coronary vasospasm of the distal left circumflex coronary artery (LCx #14 posterolateral branch) (**Figure 3**, Videos 2 and 3). Using CARTO Merge software (Biosense Webster, Irvine, California), the course of the coronary arteries from pre-procedure computed tomography imaging were merged onto the LA electroanatomic map. The endocardial LA low-voltage area that resulted from VOM ethanol ablation overlapped with the anatomic location of the spastic distal LCx artery (**Figure 4**).

MANAGEMENT

Because of the LCx vasospasm seen on coronary angiography, intravenous infusion of a vasodilator (2 mg isosorbide dinitrate) was administered, which resulted in resolution of ST-segment elevations (**Figure 2C**) and hemodynamic stability.

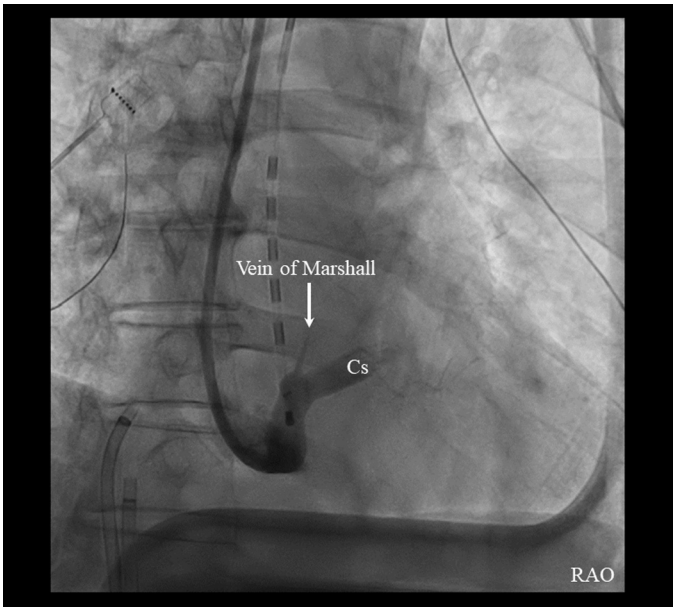
DISCUSSION

To the best of our knowledge, this is the first report of coronary arterial vasospasm after coronary venous ethanol ablation of the VOM during AF ablation. Recently, the VOM has been increasingly recognized to be a potential target site during AF ablation to achieve mitral isthmus block (1-3), vagal denervation (4), and for targeting non-PV triggers (5-7) and

ABBREVIATIONS AND ACRONYMS

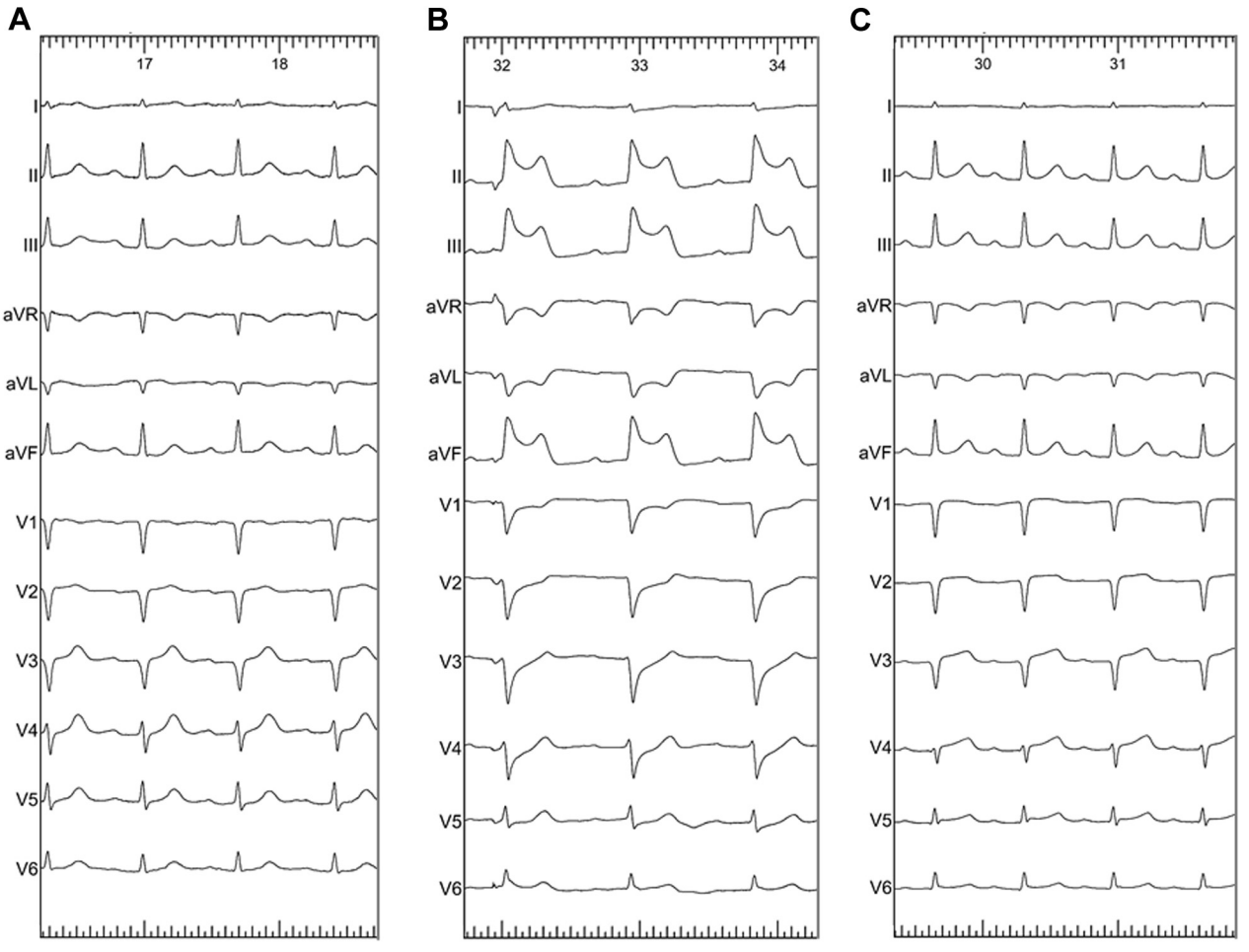
AF = atrial fibrillation
CS = coronary sinus
ECG = electrocardiogram
LA = left atrial
LCx = left circumflex coronary artery
PV = pulmonary vein
RCA = right coronary artery
VOM = vein of Marshall

FIGURE 1 Occlusive Balloon Venography of the CS



CS = coronary sinus; RAO = right anterior oblique view.

FIGURE 2 **Electrocardiograms**



(A) Baseline. **(B)** Inferior ST-segment elevation 30 min after a 98% ethanol infusion. **(C)** Post-vasodilator injection.

Marshall bundle-related atrial tachycardia (8). In those reports (1,4,6,8), 2 CS and 2 VOM dissections were observed during ethanol chemical ablation procedures, whereas no pericardial effusions or other major complications, including coronary artery abnormalities, were observed in a total of 97 cases. Depending on the length of the VOM, up to 3 or 4 balloon occlusive injections of 98% ethanol (1.0 to 1.5 ml over 90 to 120 s; total, 3.0 to 6.0 ml) were subsequently delivered in general (1,5). However, in our case, in view of the very short length of the VOM (11 mm), we instead delivered a total of 3.5 ml of ethanol at 1 time. Given the short length of the VOM, there was concern that the catheter could dislodge during ethanol infusion. Because of the technical difficulty in cannulating the VOM (possibly precluding repeated ethanol injections), we decided to give a single 3.5-ml infusion, rather than deliver multiple infusions of smaller doses. It is possible that this larger amount of ethanol may have resulted in a larger area of dispersion into the LA wall and increased the risk for coronary vasospasm. Coronary vasospasm can be induced by parasympathetic activity, and therefore, stimulation of the left inferior ganglionated plexi is a possible cause of the vasospasm. One relatively common cause of transient inferior ST-segment elevation during left-sided cardiac procedures in supine patients is air embolism

into the RCA. However, this was ruled out by urgent coronary angiography, which showed focal coronary vasospasm in the distal LCx (with a widely patent RCA), and the ST-segment elevation resolved after the administration of a vasodilator. Furthermore, the CARTO Merge software revealed the location of the spastic artery to be within the area of the LA endocardial bipolar scar resulting from the ethanol ablation. Although one cannot exclude the possibility that rapid ethanol injection of 3.5 ml all at once may have resulted in ethanol reflux into the left atrium, thus eventually entering the RCA causing transient RCA vasospasm, the finding that coronary angiography in the presence of ST-segment elevations showed a widely patent RCA casts doubt on RCA vasospasm as the cause. For these reasons, the coronary spasm appeared to be a direct complication of VOM ethanol ablation. Interestingly, the coronary spasm occurred 30 min after ethanol infusion in the VOM, which matched the time frame for completion of lesion formation extending from the posterior LA wall to the left inferior PV, as reported by Valderrábano et al. (4). This case supports the notion that the full effects of ethanol ablation can take time to occur after the infusion.

FOLLOW-UP

After more than 1 year of follow-up, this patient has not experienced any recurrent arrhythmia symptoms or chest pain and has received no medical therapy to prevent recurrence of vasospasm. The 24-h ambulatory ECG monitoring has not detected any arrhythmias.

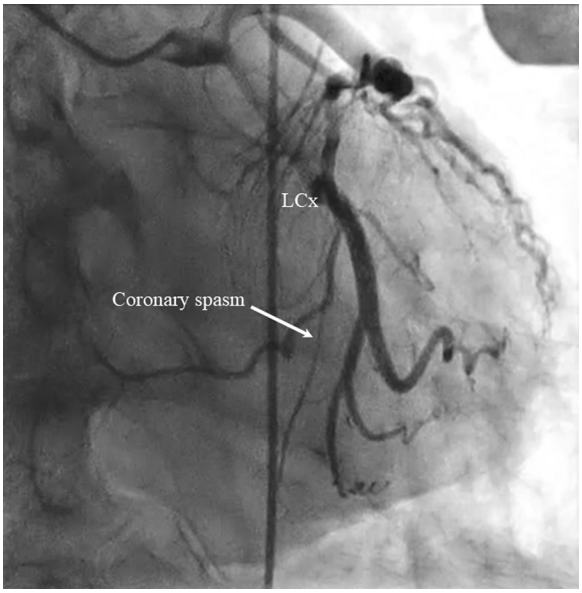
CONCLUSIONS

Our case is the first clinical report to describe coronary arterial vasospasm after coronary venous ethanol ablation during AF ablation. Although ethanol infusion into the VOM can be an effective strategy to achieve long-term freedom from recurrent AF, operators should be cognizant of the potential complications, including coronary vasospasm.

ACKNOWLEDGMENT The authors thank Mitsuhiro Makino of Biosense Webster for his contribution.

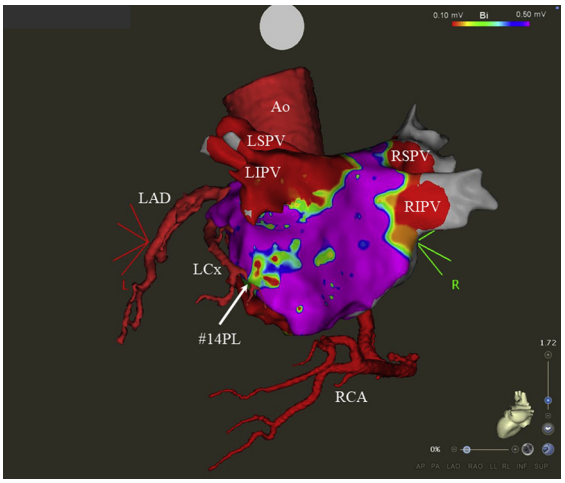
ADDRESS FOR CORRESPONDENCE: Dr. Shingo Maeda, AOI Universal Hospital, Arrhythmia Advanced Therapy Center, 2-9-1 Tamachi Kawasaki-ku, Kawasaki-city, Kanagawa 210-0822, Japan. E-mail: maeda.sn@aoikai.jp.

FIGURE 3 Coronary Vasospasm in the Distal LCx



LCx = left circumflex coronary artery.

FIGURE 4 CARTO Merge (Biosense Webster, Irvine, California) Image With Coronary Computed Tomography and Voltage Mapping of the Left Atrium After Chemical Ablation



The low-voltage area caused by the ethanol infusion is located just proximal to the spastic branch of the left circumflex coronary artery (LCx), as shown by the **arrow.** Ao = aorta; L = left; LAD = left anterior descending coronary artery; LIPV = left inferior pulmonary vein; LSPV = left superior pulmonary vein; PL = posterolateral branch; R = right; RCA = right coronary artery; RIPV = right inferior pulmonary vein; RSPV = right superior pulmonary vein.

REFERENCES

1. Okishige K, Shigeta T, Nishimura T, et al. Chemical mapping as a predictor of vein of Marshall ethanol ablative effects. Pacing Clin Electrophysiol 2020;43:47–53.

2. Baez-Escudero JL, Morales PF, Dave AS, et al. Ethanol infusion in the vein of Marshall facilitates mitral isthmus ablation. Heart Rhythm 2012;9:1207–21.

3. Chik WW, Chan JK, Ross DL, et al. Atrial tachycardias utilizing the ligament of Marshall region following single ring pulmonary vein isolation for atrial fibrillation. Pacing Clin Electrophysiol 2014;37:1149–58.

4. Valderrábano M, Chen HR, Sidhu J, Rao L, Ling Y, Khoury DS. Retrograde ethanol infusion in the vein of Marshall: regional left atrial ablation, vagal denervation and feasibility in humans. Circ Arrhythm Electrophysiol 2009;2:50–6.

5. Valderrábano M, Peterson LE, Bunge R, et al. Vein of Marshall ethanol infusion for persistent atrial fibrillation: VENUS and MARS clinical trial design. Am Heart J 2019;215:52–61.

6. Keida T, Fujita M, Okishige K, Takami M. Elimination of non-pulmonary vein ectopy by ethanol infusion in the vein of Marshall. Heart Rhythm 2013;10:1354–6.

7. Santangeli P, Marchlinski FE. Techniques for the provocation, localization, and ablation of non-pulmonary vein triggers for atrial fibrillation. Heart Rhythm 2017;14:1087–96.

8. Kitamura T, Vlachos K, Denis A, et al. Ethanol infusion for Marshall bundle epicardial connections in Marshall bundle-related atrial tachycardias following atrial fibrillation ablation: the accessibility and success rate of ethanol infusion by using a femoral approach. J Cardiovasc Electrophysiol 2019;30:1443–51.

KEY WORDS atrial fibrillation, chemical ablation, coronary vasospasm, ethanol, vein of Marshall

APPENDIX For supplemental videos, please see the online version of this paper.