Right coronary artery ostial stenosis associated with idiopathic ventricular tachycardia ablation

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Introduction

The aortic cusp has been recognized as a target of radiofrequency (RF) ablation in patients with ventricular arrhythmias.[1,2] In some patients, ventricular arrhythmias have been mapped well into the ostial coronary arteries rather than the coronary cusps.[3] Coronary artery stenosis is one of the most serious complications of RF ablation.[4–6] This is the first case report describing severe right coronary artery stenosis after RF ablation at the right coronary cusp (RCC).

Case report

A 43-year-old man with a history of two failed endocardial ablation procedures at the right ventricular outflow tract (RVOT) for recurrent, drug-resistant ventricular tachycardia (VT) was referred to our institution for repeat electrophysiologic study and catheter ablation. Twelve-lead ECG during sinus rhythm showed no remarkable abnormalities (Figure 1A). ECG recorded during VT showed inferior axis and left bundle branch block type morphology, which suggested an RVOT origin (Figure 1B). Transthoracic echocardiography showed mild dilatation of the left ventricle (diastolic diameter 58 mm) with normal left ventricular systolic function (ejection fraction 69%). Gadolinium-enhanced cardiac magnetic resonance imaging before ablation showed no evidence of scar. The patient did not have a past medical history of syncope or any family history of sudden cardiac death.

During electrophysiologic study, clinical VT was spontaneously induced, sustained for minutes, and recurred invariably with isoproterenol infusion. RF energy was delivered repeatedly at the posterior RVOT (Figure 2A), where the earliest ventricular activation of bipolar electrogram preceding the onset of QRS by 30 ms and a QS pattern of unipolar electrogram were recorded during VT (Figure 2E). Ablation using a quadripolar catheter with a 3.5-mm irrigated distal electrode and power control mode at a setting of 30–45 W resulted in the first episode of VT termination within 30 seconds of starting the sixth RF application, but VT recurred as soon as the RF energy was turned off. In total, ablation was attempted 13 times at the RVOT, but sustained VT remained. Epicardial access was obtained percutaneously via the subxiphoid area, and mapping of the epicardial area adjacent to the endocardial RVOT revealed bipolar activation preceding the onset of QRS by only 10 ms, with an rS pattern on unipolar recording. Epicardial ablation was not attempted because the VT was suspected of having an intramural origin within the posterior wall of the RVOT since a long RF ablation time was required to eliminate the tachycardia. Subsequently, the RCC was mapped after identification of the right coronary artery (RCA) ostium and confirmation of the absence of organic stenosis by coronary angiography (CAG; Figure 2C). Although an initial positive and upright electrogram was not observed in the bipolar recording made at the RCC, an early activation and a QS pattern were recorded in the bipolar and unipolar recordings, respectively, during VT (Figure 2F). Excellent pace-mapping was also obtained at that site. Figure 2C shows the relative positions of the RCC ablation site (white stars) and the RCA. The ablation site was seen to be sufficiently anterior to the RCA in the right anterior oblique view. In addition, the RCA ostium (Figure 2D, white arrows) was seen to be much higher than the ablation catheter tip. Based on these considerations, a decision was made to attempt ablation at this site (Figure 2B). RF energy was delivered using a quadripolar catheter with 4-mm non-irrigated distal electrode, using a temperature control mode with a setting of 50°C and maximum power output of 35 W. During the second RF application at the site (Figures 2B and 2F), VT was terminated transiently but recurred after RF energy was turned off. A subsequent third and final RF application at the same site resulted in VT termination in 23 seconds, and the remaining repetitive ventricular beats eventually were eliminated 80 seconds later. In summary, RF applications were applied at the RCC 3 times for a total of 195 seconds, with a maximum impedance drop of 24 Ω

KEYWORDS Catheter ablation; Ventricular tachycardia; Outflow tract; Coronary cusp; Coronary artery stenosis

ABBREVIATIONS CAG = coronary angiography; **RCA** = right coronary artery; **RCC** = right coronary cusp; **RF** = radiofrequency; **RVOT** = right ventricular outflow tract; **VT** = ventricular tachycardia (Heart Rhythm Case Reports 2015;1:13–17)

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KEY TEACHING POINTS

- This is the first case report of ostial right coronary artery stenosis associated with catheter ablation at the right coronary cusp. Thermal injury from radiofrequency application at a remote region was the most rational explanation for the stenosis.
- Our case demonstrates that coronary artery stenosis can occur even when the ablation catheter seems sufficiently distant from the ostium of the coronary artery based on superimposing catheter location on coronary angiographic images and despite impedance monitoring during radiofrequency application. These routine strategies cannot completely prevent this unusual but serious complication.
- Further diagnostic maneuvers enabling monitoring with higher temporal resolution is necessary to raise the safety of ablation at the coronary cusps. Intracardiac echocardiography likely is useful for discerning and continuously monitoring the locations of the coronary artery and catheters.

(from 117 to 93 Ω), which was not accompanied by any impedance rise. One minute after isoproterenol infusion at 1 μg/min was started after RF, the patient complained of chest discomfort. ECG showed ST-segment elevation in the inferior leads (Figure 3A). Urgent CAG revealed acute severe stenosis at the ostial RCA, which was not resolved by repeated intracoronary nitroglycerin injection (Figure 3B, top). Intravascular ultrasound examination showed eccentric intimal thickening (Figure 3C, top, white arrow), which resolved after angioplasty (Figure 3C, bottom). Both coronary artery dissection and thrombus occlusion were ruled out. Stenting was deferred at that time because subsequent percutaneous balloon angioplasty successfully improved the severity of stenosis (Figure 3B, bottom). During 18-month follow-up, CAG repeated 3 times after the ablation procedure showed gradual progression of stenosis in the ostial RCA, which eventually required stenting. The patient continued taking beta-blockers and calcium channel blockers. Fortunately for the patient, the burden of VT episodes greatly improved from almost daily to a few times per year.

Discussion

The complication rate has been shown to be low for RF ablation at the coronary cusp.[1,2,7] In the most recent report, Yamada et al[7] stated that only 1 of 90 patients with ventricular arrhythmias ablated from the coronary cusp in whom RF energy was delivered within the RCC demonstrated a complication, namely, transient sinus bradycardia followed by complete AV block. This presentation is the first case report describing RCA ostial stenosis associated with RF ablation in the RCC.

Two explanations accounting for RCA stenosis were considered: (1) thermal injury due to heat transmission by repeated RF applications within the RCC close to the ostial RCA; and (2) inadvertent and transient falling of the catheter into the RCA ostia during RF energy delivery. For the first possibility, several case reports have described distal coronary artery stenosis that likely was due to a direct thermal effect delivered via the surrounding structures.[6,8,9] The second possible explanation, a traumatic injury, was more probable in cases with proximal left coronary artery occlusion because it was thought to occur when the catheter retrogradely prolapsed across the aortic valve into the left ventricle.[4,5,10] In our case, the position of the RF catheter looked stable, impedance rise was not observed during ablation at the RCC, and we did not attempt to cross the aortic valve, all of which support the former explanation. However, ST-segment elevation did not occur immediately but became manifest only with isoproterenol infusion, which

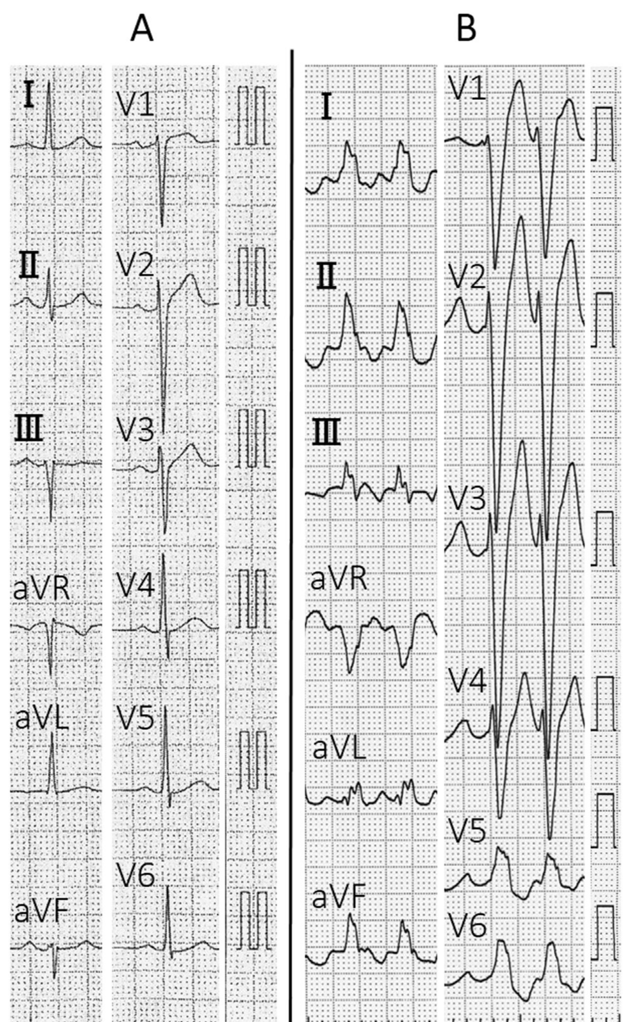

Figure 1 Twelve-lead ECGs. **A:** Sinus rhythm. **B:** Ventricular tachycardia. Inferior axis and left bundle branch block type morphology are observed.

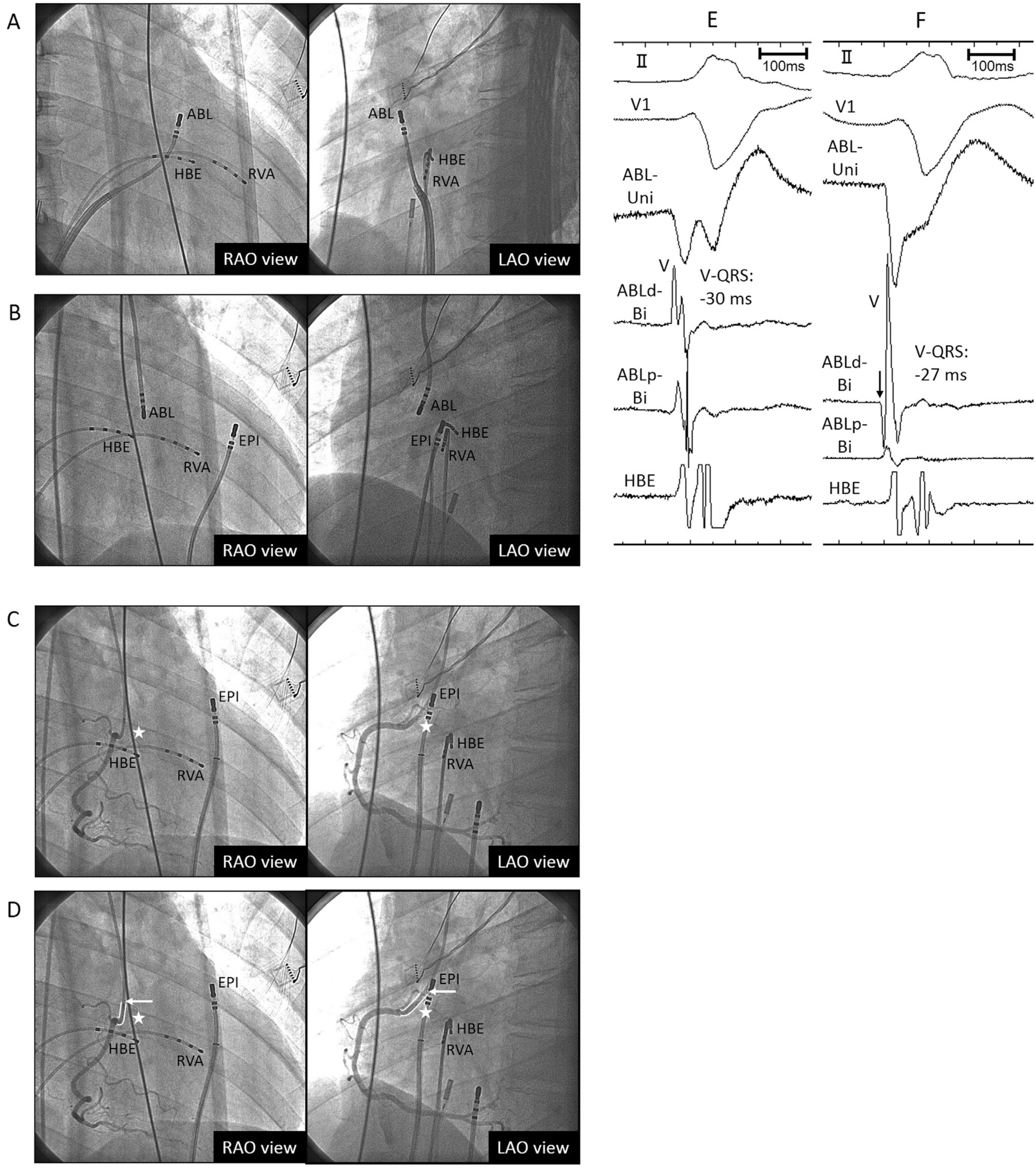

Figure 2 Fluoroscopic images of ablation sites and right coronary artery and intracardiac electrograms during ventricular tachycardia (VT). **A:** Placement of catheters during ablation at the posterior aspect of right ventricular outflow tract (RVOT). **B:** Placement of catheters during ablation at the right coronary cusp (RCC). Note the proximity of the RCC ablation site to the RVOT ablation site shown in panel A. **C:** Right coronary angiography before ablation at the RCC. The *white star* indicates the RCC ablation site from panel B, which was located anteriorly to the right coronary artery in right anterior oblique (RAO) view. **D:** Same images as panel C but with the ostium *(white arrows)* and the ostial portion *(white lines)* of the right coronary artery marked. Note that the ostium was located much higher than the distal tip of the ablation catheter (ABL) and the ostial portion ran inferiorly. **E:** Intracardiac electrogram recorded at the RVOT ablation site during VT. Local ventricular activation recorded at the distal (d) bipolar (Bi) electrode of the ABL showed an upright initial R wave preceding the onset of the QRS complex by 30 ms. Simultaneous recording of the unipolar (Uni) electrode of the ablation catheter displayed a QS pattern. **F:** Intracardiac electrogram recorded at the RCC ablation site during VT. Local ventricular activation showed not an initial positive but an early activation preceding the onset of the QRS complex by 27 ms *(arrow)* in the distal bipolar recording and exhibited a QS pattern in unipolar recording. See text for further discussion. EPI = epicardial mapping catheter inserted via subxiphoid puncture (catheter placed only for mapping, and catheter location not related with any endocardial ablation sites); HBE = His-bundle catheter; LAO = left anterior oblique; p = proximal; RVA = right ventricular apex catheter.

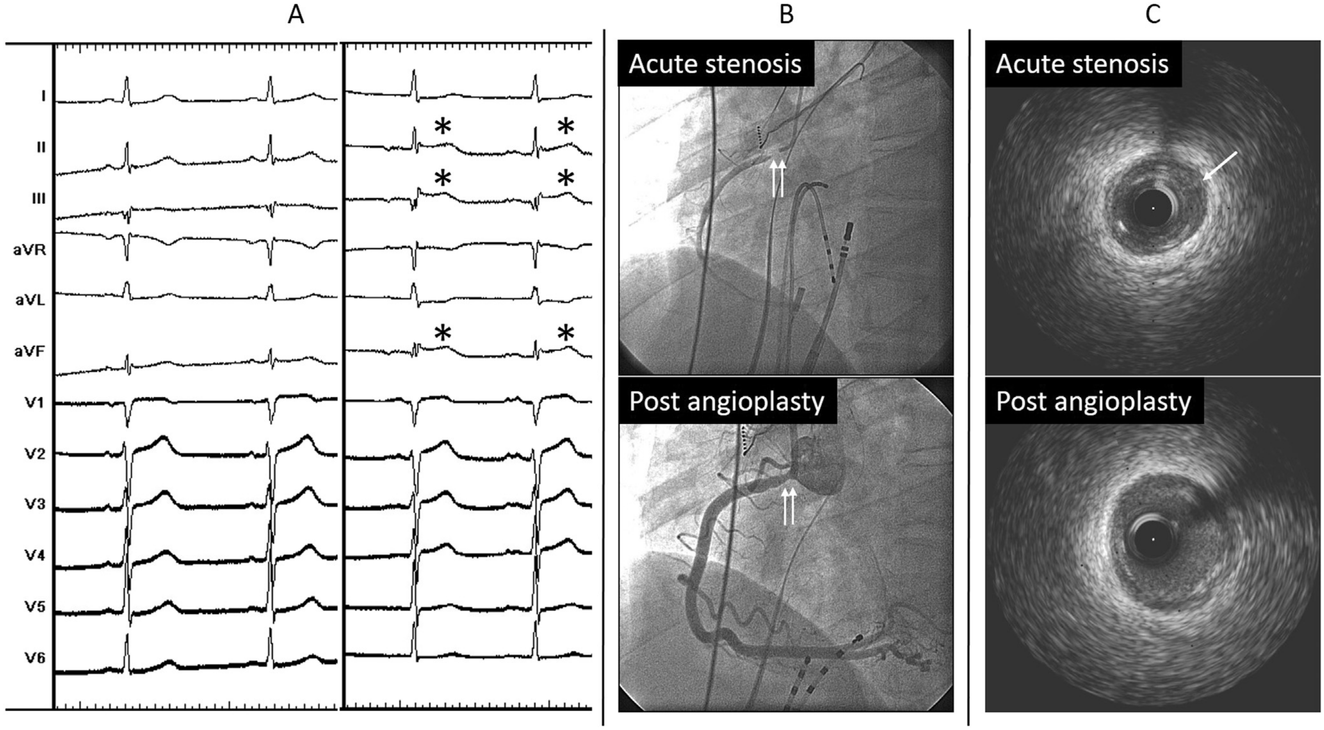

Figure 3 Right coronary artery stenosis. **A:** Twelve-lead ECGs just before **(left)** and after **(right,** *asterisks)* ST elevation in the inferior leads. **B:** Right coronary angiography (left anterior oblique view) showing acute stenosis just after ST-segment elevation was first observed **(top)** and after balloon angioplasty **(bottom).** *White arrows* indicate stenotic lesion. **C:** Intravascular ultrasound showing stenosis after repeated nitroglycerin injection **(top)** and after balloon angioplasty **(bottom).** *White arrow* indicates eccentric intimal thickening that successfully resolved after angioplasty. Neither coronary artery dissection nor thrombus was observed. See text for further discussion.

suggests to us not that a severe coronary artery stenosis might be produced at the time of ablation but rather that moderate stenosis set off by RF application rapidly progressed. In that scenario, the possibility that RF had been delivered within the RCA cannot be excluded even though an impedance rise was not observed.

Hachiya et al[2] showed that no complication was observed in 14 cases with VT ablated at the left or right coronary cusp in whom the distance from the ostium of the left or right coronary artery was >1.0 cm, respectively. In our case, we studied the location of the angiographically defined RCA relative to the proposed RCC ablation site (white stars in Figure 2C) before deciding to ablate at that site. Although we cannot completely exclude the possibility that the position of ablation catheter at the RCC was not stable because of cardiac movement, we regarded this ablation site as sufficiently remote from the RCA ostium in the right anterior oblique view in this figure.

One might argue that the ablation site indicated in Figure 2C does not seem remote from the RCA because of bending of the catheter in the direction of the RCA in the left anterior oblique view (Figure 2B). When the catheter was introduced, it was gradually bent to map the earlier activation site after careful identification of the bottom of the RCC. We believe that the possibility that we inserted the catheter directly into the RCA during mapping is very low, although the catheter inadvertently falling into the ostial coronary artery during subsequent RF applications remains possible because of cardiac movement. We think that the location of the ostial part of the RCA also would make one wonder whether the distance was sufficient. As indicated by the white arrows in Figure 2D, the ostium of the RCA was located much higher than the distal tip of the ablation catheter, which seems to ensure an adequate distance between the two. However, the ostial part of the RCA (white lines in Figure 2D) ran inferiorly. This location could make the coronary artery closer to the sinus of Valsalva and the RCC than when the RCA opened in the transverse direction. In this setting, the RCA might have been affected by heat transmission even if RF energy was applied at a site remote from the RCA ostium.

Coronary artery spasm can be an alternative explanation for the stenosis. Case reports have demonstrated diffuse intimal thickening associated with vasospasm using intravascular imaging.[11,12] Although no consensus exists regarding specific findings on intravascular imaging associated with vasospasm, because the intimal thickening observed in our case was eccentric rather than diffuse (Figure 3C, top), we believe vasospasm as the cause of the RCA stenosis is unlikely.

Based on these considerations, we conclude that thermal injury from the remote region is the most likely explanation for RCA stenosis, although the possibility of catheter dislocation and subsequent direct RF application within the RCA cannot be completely ruled out.

This case indicates the limitations of superimposing catheter location on coronary angiographic images and monitoring impedance during RF applications, although both strategies are routinely applied for preventing coronary artery stenosis when ablating at the coronary cusps. Considering that ablation at a site that was supposed to be safe for ablation still resulted in severe coronary artery stenosis reinforces the need for more diagnostic maneuvers to avoid this complication. Contrast radiography within the coronary cusp independent of selective CAG may provide more accurate information about the location of the ostial coronary artery. Intracardiac echocardiography with higher temporal resolution also may be useful to discern the relationship between the location of the coronary artery and the catheter and to monitor them continuously through the procedure.[3,13,14]

In conclusion, we presented a rare case of RCA ostial stenosis associated with RF ablation in the RCC. It should be kept in mind that when ablating at a coronary cusp, coronary artery stenosis can occur even when the ablation site likely is distant from the coronary ostium and impedance rise is not observed during ablation. Multiple diagnostic instruments such as intracardiac echocardiography should be used when ablating a coronary cusp to avoid this unusual but serious complication of RF ablation.

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