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Short Title: Guidewire Ablation Within Coronary Venous System

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Introduction:

Ablation success rate of ventricular arrhythmias (VA) varies and is associated with the origin of arrhythmia. For some patients with focal ectopies arising from epicardial or intramural locations, neither the endocardial nor epicardial ablation is always helpful, as a result of the inadequate power delivery to VA origin and its proximity to the coronary arteries1, 2. The least invasive access to target those foci is obtained via the coronary venous system (CVS). However, the ablation catheter may not be easily
maneuvered when advancing it to the distal segment of great cardiac vein (GCV) or their branches. Moreover, energy delivery may be limited due to high impedance and inadequate irrigation flow\(^3\). We herein present a case with frequent symptomatic premature ventricular complexes (PVCs) originating from left ventricular summit (LVS), was successfully ablated from the distal part of GCV using an guidewire.

**Case report:**

A 48-year-old woman with one-month history of palpitation, chest discomfort and invalid for medical therapy was referred for catheter ablation of frequent PVCs. The clinical electrocardiogram (ECG) showed that PVC was with a right bundle branch block morphology, positive R waves were in leads II, III and avF, and pseudo delta wave was in precordial QRS complex, indicating an epicardial origin in the left ventricular outflow tract (LV summit region) (figure 1A). A 24-hour ambulatory Holter ECG showed that the number of PVCs was 34,475, accounting for 31.1% of all cardiac beats in 24 hours, and transthoracic echocardiography revealed no obvious structural heart abnormalities.

After taking the informed consent of this patient, a baseline electrophysiological study was performed. Venous and arterial access was gained via the right femoral artery and vein, jugular vein, and a 10-pole diagnostic catheter (Webster®, Biosense-Webster, CA, USA) were positioned in coronary sinus. Then left ventricular mapping was performed with a 3.5 mm mapping ablation catheter (ThermoCool Navistar®, Biosense-Webster, CA, USA) and a three-dimensional electroanatomical mapping system (CARTO 3 System, Biosense-Webster, CA, USA) was used for activation
mapping. In the areas of left Valsalva sinus, no satisfactory origin foci was detected, neither under or above the aortic valve. Then, attempt was made to map aortomitral continuity (AMC), but no near-field potential was detected.

Considering that CS1-2 potential was 26 ms ahead of the QRS onset (figure 1B), the earlier activation site might be located at distal part of GCV. Firstly, mapping of the endocardial site opposite to the CS1-2 was performed, but no ideal target was detected. Subsequently, the ablation catheter was advanced into the CVS, unfortunately, we finally failed to advance catheter further despite after many attempts. To conquer this technical difficulty, we decided to switch the conventional ablation catheter to guidewire. After the patient signed informed consent, a 0.014-inch angioplasty guide wire (BMW, Abbott, CA, USA) was advanced into coronary sinus via a guiding catheter, then a micro-catheter (Fincross, Terumo, Tokyo, JAPAN) was advanced over the wire to expose only the distal 5 mm part of tip for mapping. We connected the proximal end of the guidewire to the lead V1 electrode for the record of unipolar signal, and a near-field potential by wire that preceded the QRS by 26 ms at distal part of GCV was identified (figure 1B.C). We advanced guidewire and withdrew micro-catheter, leaving approximately 25 mm of wire tip exposed for ablation. Before ablation, the coronary angiography was performed to avoid potential risk of artery injury, figure 2 showed that the exposed wire tip was located at a safe position away from the adjacent coronary arteries (more than 4 mm). Subsequently, the end part of the wire was connected to RF generator so that the uncovered part could deliver RF energy (figure 3A illustrated the basic theory of guide wire ablation). Meanwhile, we linked the end
of micro-catheter with irrigation pump for saline injection. During ablation procedure, radiofrequency energy was delivered with a starting output of 10W for 30 seconds, figure 3B showed that PVCs disappeared immediately 3 seconds later. The impedance decreased from 192Ω to 175Ω within 10 seconds, then it kept steady around 175Ω. Then increased RF energy were delivered to enhance ablation effect. When energy power increased to 20W, a sharply increased impedance occurred at 15 seconds and the ablation was immediately terminated. A carefully examination of the wire tip was performed after ablation, and no char formation was detected. During the procedure, the saline irrigation rate was at 2 ml/min, and the total ablation time was 75 seconds. It was impossible to induce PVCs immediately after 30 min of observation. ECG monitoring two hours after RF showed no ischemic ST-T change (figure 3C), and no complication occurred during the mapping or ablation procedure. During the six-month follow-up, the patient remained free of PVCs without any antiarrhythmic drugs.

Discussion:

Catheter ablation failure possess a clinical challenge for patients with epicardial or intramural VA. The efficacy of retrograde coronary venous ethanol infusion (RCVE) to treat prior failed VT has been reported⁴, but there are some potential risks of AV block, ventricular damage and pericarditis attributable to ethanol infusion⁵. Bipolar ablation is also a alternative for deeply originated arrhythmia, when targeting LVS, bipolar energy was delivered between GCV/AIV and opposite endocardium, however, this approach requires optimal anatomic conditions⁶. Other bailout approaches included half normal saline ablation and needle ablation, have also been reported⁷, but the
relative merit of these are yet to be established\textsuperscript{2,4,8}.

Guidewire, commonly used in coronary intervention, has been firstly described as a novel technique for intracoronary mapping to help guide VA ablation in electrophysiology, and it offered an alternative epicardial mapping strategy in targeting VT in those a previous endocardial ablative approach has been unsuccessful\textsuperscript{9, 10}. Romero and colleagues described a novel technique of intramyocardial guidewire ablation through a system used to treat coronary artery chronic total occlusions, and a stiff stingray guidewire was advanced through the first septal perforator into the interventricular septal myocardium for both mapping and ablation in the treatment of intramural LV summit VA, but several potential complications may occur owing to stiff tip of stingray guidewire, such as coronary artery injury and intramural hematoma\textsuperscript{11}. A case report by Efremidis and his colleagues provided a guidewire ablation technique through coronary venous system for epicardial LV summit VAs\textsuperscript{12}, and a distal 15 mm-uninsulted vision guidewire was used for both unipolar mapping and ablation at distal GCV/AIV junction site. The vascular complication and thromboembolic events related with intracoronary ablation could be probably avoided when compared to Romero’s research.

Unlike previous published research, a distal 30 mm-uninsulted guidewire covered with microcatheter was applied in our study for intravenous mapping and subsequent ablation via CVS, with the advantages of adjusting length of uncovered part in wire-tip and performing saline infusion. By linking the end of micro-catheter with irrigation pump, saline infusion during ablation is available. In distal segment of GCV or branches,
high impedance and limited cooling from surrounding blood flow are likely to limit sufficient RF energy delivery, saline infusion was useful for ensuring efficacy of ablation, because it can reduce intravenous impedance and temperature. Considering that saline infusion had a negative correlation with ablation lesion, a lower speed at 2 ml/min was chosen in our operation that allowed to maximize lesion size with a reduced baseline impedance and a relatively low risk of tissue overheating. On the other hand, length variability of wire tip, which ensure precise mapping and complete ablation, is another superiority. For mapping purpose, a shorter exposed length is achievable for recording a more accurate unipolar signal. Whereas for ablation purpose, a longer exposed length of guidewire can produce a wider lesion, with distal and proximal segments around the target site being totally covered, which increase the effectiveness of ablation, but excessively prolonging the exposed wire tip might increase the risk of collateral injury. So a optimal exposed length for ablation is associated with efficacy and safety of this approach, which need further exploration.

Based on previous published case and our present research, we can demonstrated that guidewire ablaion within distal GCV is both feasible and safe, which might be considered as a alternative approach for treating epicardial or intramural VAs inaccessible to conventional ablation catheter. Compared to ethanol infusion, lesion formation by wire is more predictable on account of its accurate targeting and limited myocardial injure. For bipolar ablation, some PVC/VT source cannot be accessed due to anatomic obstacles or out of ablation range, in this setting, guidewire ablation might be considered as a alternative approach. This study however has several limitations:
firstly, the applicability of this technique is highly dependent on whether branches of
the CS representing the origin of VAs or not, as previous report showed that only 9%
idiopathic VAs with earlist activition inside CVS\textsuperscript{13}. Secondly, without temperature
monitoring, there was potential risks of char formation around the exposed tip of wire,
so a examination of wire tip after ablation is required. Moreover, from this study, we
recognized that the process of radiofrequency energy delivery through the guidewire is not
well yet understood, and many factors, including caliber of target vessel, contact area
of wire and tissue and presence of epicardial fat could influence lesion dimention
caused by guidewire ablation, so technical advancement and more clinical studies are
needed to achieve better outcome.

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Figures:
Figure 1. A Standard 12-lead electrocardiogram (ECG, 25mm/second) morphology of the PVCs. B activation mapping (100mm/second) of PVCs by guidewire showed the earliest site of activation preceded the QRS onset by 26 ms, which is equal to the earliest activation time in CS 1-2 (-26 ms). C angiographic image depicted that the guidewire was located within GCV for mapping.
figure 2. Angiographic images of left anterior oblique (LAO 35°, A) and right anterior oblique projections (RAO 35°, B) depicted the location between the guidewire tip and the left coronary artery (LCA). Noticeably, the exposed wire tip was located at a safe position away from the LCA.

figure 3. A illustration of ablation technique using guidewire. A 0.014-inch guidewire covered with a micro-catheter was advanced into CVS, and the length of uncovered
part could be changed according to mapping or ablation purpose. The end part of guidewire was connected to RF generator via alligator clip to produce RF energy. B Cardiac tracings exhibited the effective ablations which was achieved by a guidewire at distal GCV with an output power of 10W for 3 seconds. After additional application was delivered to enhance ablation effect, PVCs was terminated completely. C. ECG morphology two hours after ablation (25mm/second).
Key Teaching Points:

1. Ventricular arrhythmia (VA) originating from epicardial or intramural locations possess a clinical challenge for catheter ablation, and coronary venous system may provide routes for mapping and ablation of these arrhythmias, but inability to deliver sufficient RF energy due to anatomical constrains, high impedance and inadequate irrigation flow may limit the efficacy of ablation.

2. As a novel technique, guidewire ablation through the coronary venous is feasible and effective for treating epicardial or intramural VA. This approach overcomes the inability to advance the traditional ablation catheter in small diameter vessels, and compared with ethanol infusion, it is more predictable to use guidewire ablation because of accurate targeting and limited myocardial injure.

3. The innovation of this technique outlined in our case is the usage of microcatheter, a guidewire covered with microcatheter can be effectively used as ‘ablation electrode’ for unipolar mapping and ablation, by moving microcatheter, length variability of wire tip is available, as well as performing saline infusion.