Unmasking of triple atrial potentials in the coronary sinus during orthodromic reciprocating tachycardia: What is the mechanism?

Itsuro Morishima, MD, PhD,* Fumio Suzuki, MD, PhD,† Yasunori Kanzaki, MD,* Yoshihiko Kamiya, CE‡

From the *Department of Cardiology, Ogaki Municipal Hospital, Ogaki, Japan, †Department of Cardiology, Fukujyji Hospital, Kiyose, Japan, and ‡Department of ECG Laboratory, Ogaki Municipal Hospital, Ogaki, Japan.

Introduction

Triple potentials have been well documented in the normal atrioventricular (AV) conduction system of the heart. Triple potentials (atrial, His bundle, and ventricular electrograms) are recorded on the His bundle electrode catheter during clinical cardiac electrophysiology.1 The second potential (His bundle electrogram) definitively represents the bridging fascicle connecting the atrium and the ventricle. Here we describe another triple potential.

Case report

An 80-year-old man with documented supraventricular tachycardia was admitted to our hospital for an electrophysiological study and catheter ablation. Baseline electrocardiogram did not show any evidence of preexcitation. The standard electrode catheters were placed at the high right atrium, para-Hisian region, and right ventricular apex. A decapolar electrode catheter (Irvine Biomedical, Irvine, CA) with 2-mm electrodes and 4-mm interelectrode spacing was introduced into the coronary sinus (CS), with the proximal pole positioned at the CS ostium.

During baseline sinus rhythm (Figure 1A and B), single atrial potentials were recorded on the CS electrode catheter with the activation sequence from the septal-to-lateral direction. No ventricular potentials were recorded on the CS electrode catheter, because the CS vessel of this patient seemed to take an anatomical course some distance away from the left AV groove. Ventricular constant pacing and ventricular extrastimulus testing revealed nondecremental, eccentric retrograde atrial activation. The earliest atrial activation was registered at mid CS (Figure 1C and D), which was identical to that during the tachycardia (Figure 1E and F). These findings seemed to definitively indicate that the tachycardia was orthodromic reciprocating tachycardia (ORT) incorporating a concealed-type left posterolateral accessory pathway (AP). The left atrium (LA) and the mitral annulus were mapped during right ventricular (RV) pacing with the use of a transseptal ablation catheter; mapping identified the earliest activation site at the posterolateral mitral annulus. We delivered radiofrequency energy toward this target site during RV constant pacing. Ventriculoatrial block occurred and the tachycardia became no longer inducible.

KEY TEACHING POINTS

- The atrial potentials recorded by an electrode catheter placed in the coronary sinus (CS) are usually composed of 2-component atrial electrograms: a dull and small electrogram representing the far-field left atrial (LA) myocardium, and a sharp and large electrogram representing the near-field CS musculature.
- An anatomical study reported that there are bridging fascicles taking an oblique course from the lateral LA myocardium to the septal orifice of the CS musculature.
- This is the first report, to the best of our knowledge, electrophysiologically documenting the presence of a bridging fascicle running obliquely from the lateral LA muscle to the septal CS musculature, which appeared as the third component of the atrial electrograms on the CS recording during orthodromic reciprocating tachycardia.

KEYWORDS

Accessory pathway; Catheter ablation; Coronary sinus musculature; Coronary sinus-left atrial bridging fascicle; Orthodromic reciprocating tachycardia; Triple potentials

(Heart Rhythm Case Reports 2020;6:657–659)

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. None of the authors have conflicts of interest to disclose regarding this article. Address reprint requests and correspondence: Dr Itsuro Morishima, Department of Cardiology, Ogaki Municipal Hospital, 4-86 Minaminakawa-cho, Ogaki, 503-8502, Japan. E-mail address: morishima-i@muc.biglobe.ne.jp.

2214-0271/© 2020 Heart Rhythm Society. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). https://doi.org/10.1016/j.hrcr.2020.06.013
Before the ablation procedure, triple atrial potentials (TP1, TP2, and TP3) were unexpectedly recorded during ORT on the CS electrode catheter (Figure 1E and F). Activation of the first component (TP1) of the triple potentials started from a site close to the AP insertion site (i.e., CS7–8 site) and propagated bidirectionally toward the lateral and the septal direction (black arrows in Figure 1F). The last component (TP2) of the triple potentials propagated from the septal-to-lateral direction (gray arrows in Figure 1F). Of note, small atrial potentials (TP3, asterisks in Figure 1F) were recorded consecutively through the CS5–6 to CS9–10 bipolar recording electrodes, with the activation sequence from the lateral-to-septal direction. These findings were also noted during RV constant pacing (Figure 1D).

What is the mechanism of the occurrence of triple CS potentials observed during ORT?

Discussion

Previous anatomical[^2] and electrophysiologic[^3][^4] studies have demonstrated that the CS atrial potentials recorded by an electrode catheter placed in the CS are usually composed of 2-component atrial electrograms (i.e., double atrial potentials): a dull and small electrogram representing the far-field LA myocardium, and a sharp and large electrogram representing the near-field CS musculature. Thus, in Figure 1F, it seems likely that the dull TP1 potential represents the electrogram of the LA myocardium, and that the sharp TP2 potential represents the electrogram of the CS musculature. Chauvin and colleagues[^2] indicated in their histological study of necropsied human hearts that the LA myocardium and the CS musculature were often separated by adipose tissue, which then included atrial myocardial fascicles connecting the CS musculature and the LA myocardium. The number
of connecting myocardial fascicles varied, ranging from 1 or 2 or more.

When the LA myocardial tissue is bridged to the CS musculature at multiple sites, both the LA myocardium and CS musculature might be activated almost simultaneously during ORT, thus resulting in an apparently single atrial potential on the CS electrode catheter. In contrast, when the bridging fascicles are limited (ideally to a single bridging fascicle), a different activation pattern may be noted, as shown in panels E and F of Figure 1. The electrophysiologic study with ORT in our patient’s rare case indicated that an impulse that was conducted retrogradely from the AP first activated the LA myocardial tissue, then was conducted through a “single” oblique connecting fascicle with a significant conduction delay, and finally reached the CS musculature at the CS9–10 recording site (Figure 2A). Because the patient had no retrograde AV nodal conduction, the impulse traveled to the atrium exclusively via the AP while pacing from the RV. Thus, the triple atrial potentials were also seen during RV pacing (Figure 1D).

We believe that this electrophysiologic finding, although very rare, strongly suggests the occurrence of conduction from the LA myocardium to the CS musculature with demonstrable successive TP3 electrograms from the CS5–6 to CS9–10 recording site. We also postulate that the long oblique course of impulse propagation via the “single” bridging fascicle from the LA myocardium to the CS musculature might have provoked delayed activation of the CS musculature. In contrast, during sinus rhythm, all of the LA muscle, bridging fascicle, and CS musculature were activated simultaneously in the same direction along the long axis of the CS; thus, single potential was recorded on the CS electrograms (Figure 2B).

An anatomical study established that bridging fascicles took an oblique course from the lateral LA myocardium to the septal orifice of the CS musculature, in support of a lateral-to-septal oblique conduction pathway. However, there have been no prior electrophysiologic studies demonstrating the presence of oblique conduction from the lateral LA myocardium to the septal orifice of the CS musculature.

In conclusion, CS triple potentials most likely represent the potentials of LA muscle, bridging fascicle, and CS musculature. It is to be noted that, to the best of our knowledge, this is the first report electrophysiologically documenting the presence of a bridging fascicle running obliquely from the lateral LA muscle to the septal CS musculature.

References
1. Josephson ME. Electrophysiologic investigation: General concepts. In: Josephson ME, ed. Clinical Cardiac Electrophysiology. Techniques and Interpretations, 2nd ed. Philadelphia: Lea & Febiger; 1993. p. 22–70.
2. Chauvin M, Shah DC, Haïssaguerre M, Marcellin L, Brechenmacher C. The anatomic basis of connections between the coronary sinus musculature and the left atrium in humans. Circulation 2000;101:647–652.
3. Antz M, Otomo K, Arruda M, et al. Electrical conduction between the right atrium and the left atrium via the musculature of the coronary sinus. Circulation 1998; 98:1790–1795.
4. Akiyama M, Kaneko Y, Taniguchi Y, et al. Coronary sinus recordings of double potentials associated with retrograde conduction through left atrioventricular accessory pathways. J Cardiovasc Electrophysiol 2004;15:1371–1376.