Case Report

Multiple forms of atypical atrioventricular nodal reentrant tachycardia with different right- and left-sided retrograde slow pathways

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Abstract
A 56-year-old man was admitted for the treatment of supraventricular tachycardia. After successful ablation of the left concealed accessory pathway, four fast-slow forms of atrioventricular nodal reentrant tachycardia associated with different right- and left-sided retrograde slow pathways were induced. The locations of retrograde slow pathway were observed at the left inferior paraseptum, left mid-septum, right inferior paraseptum, and coronary sinus ostium, respectively. These retrograde slow pathways formed the integral limb of each tachycardia because conduction block of each slow pathway by catheter ablation was associated with the termination of tachycardia or abrupt change in the atrial activation sequence.

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Introduction
Radiofrequency catheter ablation of the slow pathway is an established treatment for atrioventricular nodal reentrant tachycardia (AVNRT) [1]. Slow pathway conduction can be eliminated by radiofrequency energy application to the right inferior paraseptum in most slow-fast and fast-slow forms of AVNRT; however, it has been reported that standard right-sided ablation was ineffective for the ablation of the slow pathway and required left-sided catheter ablation in rare cases with the slow-fast and fast-slow forms of AVNRT [2–4]. We report a case of multiple fast-slow forms of AVNRT associated with multiple different right- and left-sided retrograde slow pathways that were successfully eliminated by right- and left-sided approaches.

Case report
A 56-year-old man was admitted to our hospital for catheter ablation for paroxysmal supraventricular tachycardia. No structural heart disease was detected on physical exami-
A 12-lead surface electrocardiogram during sinus rhythm showed no abnormal findings. Electrophysiological study demonstrated AV reciprocating tachycardia (AVRT) using a left concealed accessory pathway with a cycle length of 350 ms (Figs. 1 and 2a, AVRT). Tachycardia was reset by single right ventricular extrastimulation delivered during the refractory period of His bundle and showed a V—A—V pattern following entrainment by right ventricular stimulation. Atrial mapping was then performed using a 7-Fr large tip deflectable quadripolar electrode catheter, which was advanced into the left atrium by the transseptal approach. The earliest atrial activation during AVRT was observed at the superolateral mitral annulus (2:30 time position in the left anterior oblique view) (Fig. 1, site K in the right panel; Fig. 2a). Radiofrequency energy application to the earliest atrial activation site successfully eliminated ventriculo-atrial conduction via the concealed left superolateral accessory pathway. Subsequently, the fast-slow form of AVRT was induced (Fig. 1, AVNRT-1; Fig. 3, AVNRT-1). A diagnosis of AVNRT was made by previously established criteria [5]. Mapping of the right and left atrium revealed that the earliest atrial activation was at the left inferior parasepulchral (Fig. 1, site 1 in the right panel; Fig. 3, AVNRT-1). Application of radiofrequency energy to the left inferior parasepulchral terminated tachycardia immediately after the onset of energy application (Fig. 2b), suggesting that the retrograde slow pathway at this ablation site was an integral limb of the circuit. Although AVNRT-1 was rendered non-inducible after energy application to the left inferior parasepulchral, a different fast-slow form of AVNRT (AVNRT-2) was then induced (Fig. 1, AVNRT-2; Fig. 3, AVNRT-2). Intra-atrial mapping revealed that the earliest retrograde atrial activation site during AVNRT-2 was at the left mid-septum (Fig. 1, site 1 in the right panel; Fig. 3, AVNRT-2). As shown in Figs. 1 and 3, the morphology of the P wave of the surface 12-lead electrocardiogram and the atrial activation sequence on intracardiac electrograms in AVNRT-2 differed from those in AVNRT-1 (Figs. 1 and 3). The negative deflection of P wave in leads II, III, and aVF during AVNRT-2 was slightly shallower than those in AVNRT-1 and the positive deflection of the P wave in lead V1 during AVNRT-2 was lower than that during AVNRT-1 (Fig. 1). Also, the intra-atrial activation interval between CS 9-10 and HRA 7-8 during AVNRT-2 was shorter than during AVNRT-1 (45 ms vs 55 ms) (Fig. 3). The atrial electrogram at CS 7-8 was observed earlier than that at CS 9-10 during AVNRT-1. However, the atrial electrogram at CS 9-10 was observed earlier than that at CS 7-8 during AVNRT-2. In addition, atrial activation time in the CS during AVNRT-1 was shorter than that during AVNRT-2 (13 ms vs 16 ms) (Fig. 3). Radiofrequency energy application to the left mid-septum (site 1 in Fig. 1) during AVNRT-2 produced an abrupt change in the cycle length and intracardiac activation sequence (Fig. 2c). The tachycardia cycle length was abruptly prolonged from 360 to 390 ms accompanied by
Multiple different retrograde slow pathways in atrioventricular nodal reentrant tachycardia

Figure 2  Panel a: Surface electrocardiogram I, II, and V1 and intracardiac electrograms during atrioventricular reciprocating tachycardia. The ablation catheter (ABL) is located at the earliest atrial activation site (2:30 time position in the left anterior oblique view; MV 2:30). Panel b: Recording during AVNRT-1 at the onset of radiofrequency energy application. The ablation catheter (ABL) is located at the left inferior paraseptum, where the earliest atrial electrogram was recorded during AVNRT-1. Panel c: Recording during radiofrequency energy application to the mid-septum of the left atrium, where the earliest retrograde electrogram was observed during AVNRT-2. AVNRT, atrioventricular nodal reentrant tachycardia; CS, coronary sinus; HB, His bundle; RV, right ventricle.

Figure 3  Surface electrocardiograms I, II and V1 and intracardiac electrograms during AVNRT-1, -2, -3, and -4 are shown. The ablation catheter (ABL) is located at the earliest atrial activation site (EAAS) in each tachycardia. See text for discussion. AVNRT, atrioventricular nodal reentrant tachycardia; CS, coronary sinus; HB, His bundle; HRA, high right atrium; RV, right ventricle.
delayed activation of the atrial electrogram at the ablation site, suggesting a shift in the retrograde limb of tachycardia and transition of the tachycardia circuit to a different form of tachycardia by ablation (Fig. 2c). After elimination of AVNRT-2, we remapped the left atrium during subsequent fast-slow AVNRT (AVNRT-3); however, the earliest atrial electrogram was not in the left atrium, but was observed at the right inferior paraseptum during AVNRT-3 (Fig. 1, site 3 in the right panel; Fig. 3, AVNRT-3). The morphology of the P wave on the surface 12-lead electrocardiogram and the atrial activation sequence on intracardiac electrograms in AVNRT-3 were different from those in AVNRT-1 and -2 (Figs. 1 and 3). Although the atrial electrograms at CS 9-10 during AVNRT-1 and -2 were observed 55 and 45 ms earlier than those at HRA 7-8, the atrial electrogram at CS 9-10 was observed 70 ms earlier than that at HRA 7-8 during AVNRT-3 (Fig. 3). In addition, atrial activation time in the CS during AVNRT-3 was longer than those during AVNRT-1 and -2 (32 ms vs 13 and 16 ms, respectively) (Fig. 3). Furthermore, atrial activation sequence from HRA 1-2 to 9-10 during AVNRT-3 was different from that during AVNRT-1 and -2 (Fig. 3). Subsequent application of radiofrequency energy to site 3 terminated AVNRT-3 and eliminated retrograde slow pathway conduction at site 3; however, another different fast-slow AVNRT (AVNRT-4) was induced (Figs. 1 and 3). The earliest atrial electrogram was observed at the coronary sinus ostium during AVNRT-4 (Fig. 1, site 4 in the right panel). P wave morphology on the surface 12-lead electrocardiogram and intracardiac activation sequence during AVNRT-4 differed from those during AVNRT-1, -2, and -3 (Figs. 1 and 3). Also, the atrial activation time in the CS during AVNRT-4 differed from those during AVNRT-1, -2, and -3 (Fig. 3). Radiofrequency energy application to the coronary sinus ostium (site 4 in Fig. 1) terminated AVNRT-4 and eliminated retrograde slow pathway conduction. After this energy application, tachycardia was rendered non-inducible.

Discussion

Our case presented multiple forms of fast-slow AVNRT using different multiple right- and left-sided retrograde slow pathways. Indeed, change in the retrograde slow pathway conduction via the retrograde right- and left-sided slow pathways was associated with the change in the intracardiac activation sequence. These different retrograde slow pathways formed the integral limb of each tachycardia. This was confirmed by the finding that the conduction block of each slow pathway by radiofrequency energy application was associated with the termination of tachycardia or shift in the atrial activation sequence accompanied by a change in the tachycardia cycle length. Of interest, the difference in the tachycardia cycle length among tachycardias was mainly due to the difference in the HA interval. This may reflect the different retrograde conduction time among different retrograde slow pathways or it might be caused by the change in the autonomic tone.

Our observations confirmed the previous case of the common form of AVNRT, in which the successful ablation site was in the left mitral annulus [2]. Left-sided ablation of the retrograde slow pathway in the fast-slow form of AVNRT has also been reported previously [3,4]. However, the successful ablation site of the eccentric atypical AVNRT was in the coronary sinus ostium and, to our knowledge, it has never been shown in the left atrial mitral annulus. Previously, Inoue and Becker provided histologic evidence of both rightward and leftward inferior extensions and they speculated that these extensions may form the substrate of the slow pathway in AVNRT [6]. Katritsis et al. demonstrated the presence of the left inferior extensions electrophysiologically [7]. Based on these findings, they suggested that a right or left circuit may occur in AVNRT [7]. Thus, these multiple extensions might be the substrate of the right- and left-sided retrograde slow pathways observed in our case.

References