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Original Article

Usefulness of entrainment mapping using the activation sequence of the last captured excitation in complex dual-loop atrial tachycardia

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ABSTRACT

Background: Electroanatomical mapping is useful for locating the atrial reentrant circuit, but analysis of the dynamic relation of the reentrant circuit is sometimes difficult. This article describes three cases of complex dual-loop reentrant atrial tachycardia analyzed by entrainment mapping using not only the postpacing interval (PPI) but also the activation sequence of the last captured beats.
Methods: Case 1 was dual-loop reentry consisting of the tricuspid annulus (TA) and a localized atrial reentry at the coronary sinus (CS) ostium with different exit sites to the right and the left atrium that was cured by catheter ablation at the CS ostium showing fractionated potential. Case 2 was dual-loop reentry around the TA and the superior trans-septal incision line. Case 3 was dual-loop reentry around the TA and longitudinal dissociation along the cavo-tricuspid isthmus.
Results: In Cases 1 and 2, entrainment with a shorter pacing cycle length demonstrated antidromic penetration to the circuit and changed the activation sequence of the last captured beat depending on the anatomical relation of the reentrant circuit. In Cases 1–3 with dual-loop reentry, the excitation wavefront induced by stimulation entered one circuit after going around the other; thus, the penetration to the other reentry circuit became the second beat after the stimulus (one lap behind).
Conclusions: The PPI is obtained from the pacing site only, but the last captured beat could be obtained from all electrodes. It is advantageous to use the information from all available electrode recordings to determine the dynamic relation between complex dual-loop reentrant circuits.

1. Introduction

Electroanatomical mapping is useful for locating a possible reentrant circuit, but it has limitations in terms of analyzing the functional property of the circuit [1,2]. Entrainment mapping using the postpacing interval (PPI) and the activation sequence of the last captured beat has been used for analyzing complex reentrant tachycardia circuits [3,4]. This article describes three cases of complex dual-loop reentrant atrial tachycardia analyzed by conventional entrainment mapping without using a three-dimensional PPI mapping system. Case 1 was dual-loop reentry consisting of the tricuspid annulus (TA) and a localized atrial reentry at the coronary sinus (CS) ostium with different atrial connection sites to the right and left atrium. Case 2 was dual-loop reentry around the TA and the superior trans-septal incision line. Case 3 was dual-loop reentry around the TA and longitudinal dissociation along the cavo-tricuspid isthmus. In these three cases, analysis of the activation sequence of the last captured beat was useful for clarifying the dynamic relation of reentrant circuits.

2. Materials and methods

Electrophysiological study and radiofrequency catheter ablation was performed using standard methods after obtaining written informed consent. Entrainment mapping was performed from several atrial sites during tachycardia at a cycle length of 20–50 ms shorter than the tachycardia cycle length (TCL). A shorter pacing cycle length was selected on purpose to demonstrate the deeper antidromic penetration to the reentrant circuit. The PPI from the pacing site and activation sequence of the last captured excitation from all available electrodes was analyzed to determine the composition of reentrant circuits. The last captured beat was defined as the last activation where the preceding cycle length was the same as the pacing cycle length after the termination of overdrive pacing. A radiofrequency catheter ablation was performed to achieve a target temperature of 55 °C for a maximum power of 30–50 W.

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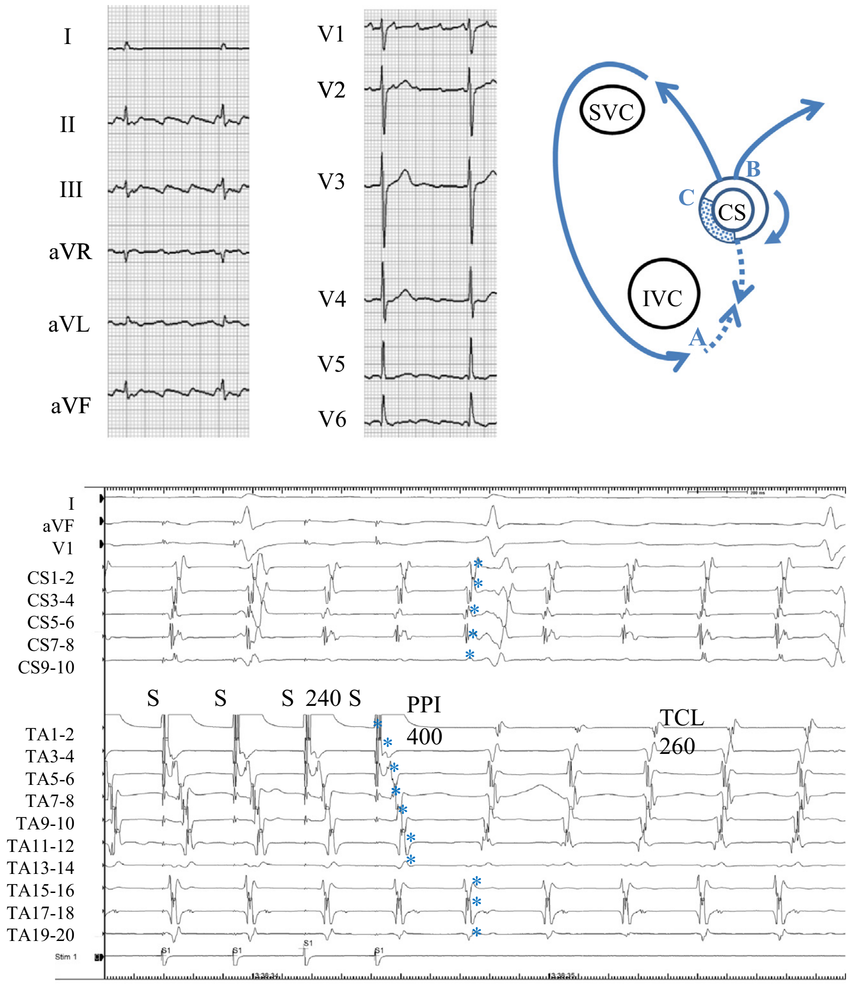

Fig. 1. Twelve-lead ECG during atrial tachycardia (upper-left), schema of the tachycardia (upper-right), and entrainment from the cavo-tricuspid isthmus (lower) in Case 1. *Upper left*: During atrial tachycardia, the saw-tooth pattern of the P wave suggested the common type of atrial flutter. *Upper right*: Schema of the localized reentry at the coronary sinus (CS) ostium with different exit sites to the right and the left atrium. SVC=superior vena cava, IVC=inferior vena cava. *Lower*: Simultaneous recordings of surface ECG leads I, aVF, and V1, intracardiac recordings along the tricuspid annulus (TA) from the low lateral right atrium (TA 1-2) to the high right atrium (TA 19-20), and recordings along the CS. During atrial flutter, counter-clockwise conduction around the TA appears. Note that after entrainment from the cavo-tricuspid isthmus, the last captured beats (*) at the right atrial septal wall (TA 15-16 to TA 19-20) and at the CS were the second beat after the stimulus. The post-pacing interval (PPI) of 400 ms was prolonged compared with the tachycardia cycle length (TCL) of 260 ms.

Dual-loop reentry was defined as reentry involving two simultaneously coexisting loops sharing a common pathway of unidirectional activation. Two reentrant circuits may have different TCLs. The reentrant loop having the shorter TCL becomes the dominant circuit, and the remaining reentrant loop with the longer TCL is continuously entrained by the activation wavefront from the dominant circuit.

3. Results

3.1. Case 1: Dual-loop reentry consisting of the TA and a localized reentry at the CS ostium with different exit sites

An 83-year-old man experienced palpitations on effort one month before admission. His twelve-lead ECG showed atrial flutter at a heart rate of 60/min (Fig. 1, upper). He was referred for ablation of atrial flutter. A 20-pole TA catheter with 5-mm inter-electrode spacing was positioned in the right atrium parallel to the TA, and the distal electrode (TA 1-2) was located in the proximal region of the cavo-tricuspid isthmus. Another 10-pole electrode catheter with 5-mm inter-electrode spacing was positioned at the CS.

In this patient, the TCL was 260 ms and the CS activation was proximal to distal (Fig. 1, lower). Activation mapping showed counter-clockwise rotation around the TA, suggesting the common type of atrial flutter, although the timing of activation from TA15-16 to TA19-20 was simultaneous. Entrainment from the cavo-tricuspid isthmus at a cycle length of 240 ms induced a long antidromic penetration through the right atrial free wall (TA1-2 to TA13-14) and a prolonged PPI of 400 ms compared with the TCL. The last captured beats (*) at the proximal TA (TA 15-16 to 19-20) and at the CS (CS 1-2 to 9-10) were the second beat after the stimulus (Fig. 8A). These findings suggested that the cavo-tricuspid isthmus was not involved in the dominant reentrant circuit.

During entrainment from the CS proximal (CS 7-8) at a cycle length of 240 ms, the last captured beats (*) at the TA (TA 3-4 to 19-20) and at the CS distal (CS 1-2 to 5-6) were the second beat after the stimulus (Fig. 2, upper). However, entrainment from the same site at a shorter cycle length of 220 ms changed the response pattern. The last captured beat (*) at the TA (TA 3-4 to 19-20) was the second beat after the stimulus and the last captured beat (*) at the CS (CS 1-2 to 5-6) became the first beat after the stimulus (Fig. 2, lower). A value of 260 ms and 270 ms for the PPI at the CS proximal suggested that the CS proximal was located on the dominant reentrant circuit.