Bidirectional Ventricular Tachycardia Caused by a Reentrant Mechanism With Left Bundle Branch Block Configuration on Electrocardiography

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Reentrant bidirectional ventricular tachycardia (VT) with left bundle branch block (LBBB) configuration was diagnosed in a 54-year-old woman who showed 2 types of VT: QRS morphologies of LBBB with inferior axis and LBBB with superior axis. The development of VT with a superior axis was preceded by VT with inferior axis and/or both configurations of VT in alternate beats exhibiting bidirectional VT. The electrophysiological study demonstrated reproducible induction of both types of VT by programmed ventricular stimulation and both types of VT were entrained. Using conventional pace mapping and electro-anatomical mapping methods, radio-frequency energy applications at the 2 exit sites of the reentry path successfully terminated both types of VT and the patient was free from VT attacks for more than 15 months. (Circ J 2008; 72: 1373–1377)

Key Words: Bidirectional ventricular tachycardia; Electro-anatomical mapping; Entrainment; Radiofrequency catheter ablation

Bidirectional ventricular tachycardia (VT) has a rapid ventricular rhythm with alternating QRS morphologies on electrocardiography (ECG). Although bidirectional VT generally develops as consequence of digitalis toxicity or in patients with catecholaminergic polymorphic VT, its mechanism is suggested to be triggered activity or abnormal automaticity and reentry is generally assumed as the least probable mechanism. As for the QRS morphology, most bidirectional VTs have the right bundle branch block (RBBB) type configuration with right- and left-axis deviations, or alternation of RBBB and left bundle branch block (LBBB) patterns on ECG, and LBBB with different QRS axes occurs less often. We report a case of reentrant bidirectional VT with LBBB configuration of alternating inferior and superior axes. Using conventional pace mapping and electro-anatomical mapping methods, radiofrequency energy applications at the 2 exit sites of the reentry path successfully terminated both types of VT.

Case Report

A 54-year-old woman was first referred to hospital for evaluation of palpitation and repetitive attacks of VT in March 2004. She had no past history of cardiac problems and no family history of sudden cardiac death. On her first admission, her ECG during a palpitation had disclosed VT of LBBB morphology with inferior axis. The electrophysiological study (EPS) demonstrated reproducible VT, with a similar morphology to that of the clinical VT, by programmed ventricular stimulation (PVS) with entrainment. Radiofrequency catheter ablation (RFCA) at the right ventricular outflow tract (RVOT), assumed to be an exit site of the reentry pathway, had completely eliminated inducible VT according to the results of PVS. She was clinically free of symptoms for 9 months until December 2004, when she experienced a recurrence of VT.

She was re-admitted in February 2005 for further evaluation. Her 12-lead ECG in sinus rhythm showed left-axis deviation with incomplete RBBB pattern. This time, her clinical VT showed 2 distinct morphologies of QRS on ECG: one was LBBB with inferior axis (VT1) and the other was LBBB with superior axis (VT2). VT1 had a similar morphology to that recorded previously in March 2004, except for higher QRS voltages in leads II, III, and aVF, and different notch configurations in the LBBB pattern in leads V5 and V6. Both types of VT appeared on the same day during admission and her hemodynamic conditions were stable during both attacks. On another occasion, the QRS morphologies of VT1 and VT2 developed an alternative beat, manifesting as a bidirectional VT (Fig 1). VT2 usually appeared after VT1 and/or development of bidirectional VT.

Carotid sinus massage and adenosine did not suppress the VT, but intravenous administration of procainamide effectively terminated both types.

Her physical examination, including eyes, skin and central and peripheral nervous system, was normal. Her signal-averaged ECG (SAECG) was positive for late potentials (RMS40 = 4.53 μV). Chest X-ray and cardiac magnetic resonance imaging were normal. Ventricular angiography dem-

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Fig 1. Twelve-lead electrocardiography during ventricular tachycardias (VTs). Two distinct QRS morphologies of VT are recorded: VT1 is left bundle branch block (LBBB) with inferior axis, and VT2 is LBBB with superior axis. On some occasions, both morphologies (VT1 and VT2) are present in alternating beats, exhibiting a bidirectional VT.

Fig 2. CARTO mapping and entrainment pacing during VT. (A) Activation map recorded by the CARTO system. (Top) Anteroposterior (AP) view, (Bottom) left lateral (LL) view. Entrainment pacing stimuli were applied at the small blue tag (anterolateral site of the right ventricular outflow tract (RVOT)) and at the green tag (septal site of the RVOT), small white tags indicate areas of fragmentation. The activation map shows a focal activation pattern in which the earliest activation is at the septal site of the RVOT. (B) Intracardiac electrograms during entrainment pacing. (B)-1: Pacing at the site of the blue tag entrained VT1 and the QRS morphology changed to that of VT2. (B)-2: Pacing at the site of the green tag shows concealed entrainment with VT1. The post-pacing interval was equal to the cycle length (CL) of VT1 and the stimulus-QRS (S-QRS) interval was nearly equal to the local electrogram-QRS. A relatively short S-QRS interval (30 ms, 9% of VT1 CL) indicates a point located near the exit site of VT1. Ab, electrogram recorded by ablation catheter; RVA, electrogram at the right ventricular apex. Other abbreviations see in Fig 1.
Reentrant Bidirectional VT With LBBB demonstrated reduction of wall motion and reduced ejection fraction (EF) (left ventricular (LV) EF=44%, right ventricular (RV) EF=37%). We also noticed a small bulge in the infundibular portion of the RV but it was not big enough to be an aneurysm. Endocardial biopsy samples from the RV revealed mild infiltration of fatty tissue and the presence of hypertrophic myocytes, but histological diagnosis was unequivocal for a definite disease entity.

EPS and RFCA

After an informed consent was obtained from the patient, an EPS was performed using a conventional mapping method and a 3-dimensional electro-anatomical mapping (CARTO) system with 7Fr deflectable quadripolar mapping and ablation catheter (Biosense Webster). Both VT1 and VT2 were reproducibly induced by PVS and entrainment pacing from the RV apex during VT showed manifest and progressive fusion. The cycle length (CL) of the induced VT1 was 340 ms and that of VT2 was 400 ms, with stable hemodynamics. A single extrastimulus delivered from the RVOT during VT2 could reset the tachycardia and changed the QRS configuration to that of VT1.

The RV voltage map produced by the CARTO system showed scar areas, as defined by voltage amplitude<0.1mV, and without local capture by pacing of the maximum output (20 mA × 2.0 ms) around the subvalvular area of the RVOT. Low voltage areas as defined by a voltage amplitude between 0.1 and 1.5 mV with multiple fragmentation were located below the scar areas. The RV activation map by CARTO during VT1 demonstrated a focal pattern of impulse propagation, in which the earliest excitation was detected on the septal side of the RVOT (Fig 2A). This area was a few centimeters lower than the point of energy application in the RFCA session in March 2004.

Entrainment pacing during VT1 delivered at the anterolateral site of the RVOT showed a similar QRS morphology of VT completely transformed into that of VT1 after 23 s of RFCA. Other abbreviations see in Figs 1, 2.

Discussion

Bidirectional VT is generally considered to be triggered activity because both its mechanism and its reentrant mechanism are believed to be rare1–3 as conduction block in either bundle branch or fascicle has to develop in alternating beats or be present at 2 different exit sites of a reentrant impulse utilizing every other beat. The combination of either condition may not occur easily except by chance. The mechanism of the 2 types of VT in the present patient appeared to be reentry because there was reproducible induction and termination by PVS, and because of observa-

Fig 3. Electrograms recorded during radiofrequency catheter ablation (RFCA) energy application for VT1. (Left) VT1 changes to bidirectional VT 15 s after the start of RFCA energy application. During RFCA, the CL of VT1 was not prolonged. (Right) QRS morphology of VT completely transforms into that of VT1 after 23 s of RFCA. Other abbreviations see in Figs 1, 2.
tion of the entrainment phenomenon, although the supporting evidence for VT2 was less clear than that for VT1, as the short-lived appearance of the former during EPS did not allow detailed exploration. By combining the results of CARTO mapping and pace mapping the possible target exit site could be determined for VT1 and RF energy application at that site easily terminated the tachycardia. In the case of VT2, the site was determined by pace mapping alone, with successful elimination of the tachycardia.

From these results, we present 2 hypothetical VT circuits (Fig 4) which have a common critical pathway (CP) but 2 different exit pathways. If 1 exit pathway has fast conduction with a long refractory period (pathway 1) and the other has slow conduction with a short refractory period (pathway 2), a stimulus (N) will usually excite the myocardium through pathway 1, forming the VT1 configuration. If the next stimulus (N+1) coincides with the refractory period of pathway 1, it excites the myocardium through pathway 2 and forms the VT 2 configuration. Bidirectional VT can be explained as every other stimuli coinciding with the refractory period of pathway 1 and thus using pathway 2 as the exit, creating an impulse that exhibits alternating QRS morphologies. There is, however, a limitation to this interpretation, as we could not perform pacing from the CP during each VT in order to observe manifest entrainment because of the short duration of VT2 and because of technical difficulties. Therefore, the presence and exact location of the CP were not proven in this case.

VT with 2 different morphologies utilizing different exit sites of the reentrant circuit may not be so extremely rare. In such cases, the different VT usually have different time frames. A unique feature of the present case, however, was the development of 2 morphologies of VT in alternating beats, appearing as either bidirectional VT or attacks of 1 type of VT that transformed into another type.

We cannot make a definitive diagnosis of the basal heart disease. Her history of repetitive LBBB-type VT, plus the results of SAECG and angiography suggest arrhythmogenic RV cardiomyopathy (ARVC). LV angiography showed reduced wall motion, suggesting a disease process similar to ARVC extending into the LV wall. Another differential diagnosis is cardiac sarcoidosis, but is less likely because of negative findings for physical examination, chest X-ray, and cardiac histology.

VT caused by ARVC is mostly caused by macro-reentrant circuits and therefore mapping of the best target site for RFCA can be achieved by entrainment mapping with or without electro-anatomical mapping. However, in this case the CARTO map of VT1 demonstrated a focal activation pattern, which is not consistent with a macro-reentrant pattern but fulfils the criteria for entrainment. The possible reasons for these results are first, a relatively short reentrant circuit, and second, that nearly all of the circuit of VT1 was located in the epicardial side and only the exit was situated in the endocardial side, as detected by endocardial mapping. As the CARTO map during VT1 showed a focal pattern, it was unable to demonstrate all the details of the scars and pathways. We strongly suspect, however, that the distribution of the low voltage areas with multiple fragmentation and delayed potentials in the RVOT could form a substrate for reentry.

An implantable cardioverter defibrillator was rejected by the patient, so continuous follow-up is necessary to detect relapse of the VT and for timely diagnosis of the basal disorder.
Conclusion

In a case of reentrant mechanism of bidirectional VT originating from the RVOT, there were 2 exit sites that were successfully ablated by RFCA after using the combination of the CARTO system and conventional mapping during the tachycardia.

References