Ventricular Tachycardia Originating From the Right Ventricular Outflow Tract Terminated by Steam Pop

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ABSTRACT
Steam pops occur when tissue temperature exceeds 100°C. This can lead to tissue disruption and sometimes subsequent cardiac tamponade, especially in thin-walled structures such as the right ventricular outflow tract (RVOT). This event is potentially disastrous; however, in our case, ventricular tachycardia originating from the RVOT was successfully terminated by a steam pop, although it required pericardiocentesis and drainage.

Key words: • catheter ablation • complication • ventricular tachycardia

Introduction
Steam pops are infrequent in radiofrequency (RF) ablation for ventricular tachycardia (VT); although they have been reported to occur in only 1~1.5% of all RF ablations, they can cause cardiac tamponade, especially in the right ventricular outflow tract (RVOT).1-3

Case Report
A 57-year-old woman presented to our emer-
sedation, biphasic direct cardioversion (50 J) was performed twice; however, the tachycardia continued, and her BP dropped to 70/56 mmHg. A flecainide infusion was started, and the tachycardia stopped during that infusion. Laboratory test results were within normal limits, and a transthoracic echocardiogram showed normal left ventricular ejection fraction (64%) and mild...
Figure 3. Electrogram when the ventricular tachycardia originating from the right ventricular outflow tract was terminated. Presystolic potential at the ablation catheter (ABLd) was earlier than the surface QRS onset at lead V2 by approximately 22 ms.

Figure 4. Electrogram when the steam pop developed
mitral regurgitation (grade I). The next day, an electrophysiology study was performed. With the patient fasting and unsedated, a 6 Fr quadripolar catheter was placed in the right ventricular (RV) apex and a 7 Fr deflectable non-irrigation catheter (Celsius™, Biosense Webster, Diamond Bar, CA, USA) via an SR-0 sheath (St. Jude Medical, St. Paul, MN, USA) was placed in the RVOT via the right femoral vein. After performing an angiogram of the RVOT area, 3D electroanatomic mapping (EnSite™, St. Jude Medical) was performed. The baseline rhythm was sinus with occasional ventricular premature contractions (VPC), whose morphology was compatible with the clinical VT. VT originating from the RVOT (cycle length 400 ms) was repeatedly induced by the RV burst pacing. The earliest ventricular potential was recorded at the left–superior area between the free wall and septum of the RVOT, and pace–mapping showed an identical VT morphology. The presystolic potential at the ablation catheter was earlier than the surface QRS onset at lead V2 by approximately 22 ms, and the 3D mapping point was compatible with the point. During RF ablation at the point on the VT state, VT was successfully terminated (Figures 2 and 3). However, some VPCs and non–sustained VTs remained after several additional ablations, which might have been associated with improper power delivery because of impedances and temperature limitations. Therefore, we changed the ablation catheter to a 7 Fr unidirectional irrigated form (Celsius™ Thermocool®, Biosense Webster) for increased power delivery. RF ablation (45 W, with the maximum catheter tip temperature set to 50°C) was repeated at the same ablated site. Catheter irrigation was started automatically at a flow rate of 30 mL/min at the start of the ablation. During ablation, a sudden audible steam pop developed (Figure 4). Energy delivery was immediately stopped after the pop occurred. However, the patient’s BP suddenly dropped and she became stuporous. After confirmation of cardiac tamponade by

*Figure 5. Final electrogram after the steam pop showing sinus rhythm*
portable transthoracic echocardiography, pericardio-
centesis with drainage was performed. After drainage, the patient’s BP improved to 100/70 mmHg. Fortunately, after this event, no more VPCs or VTs were observed for >30 min (Figure 5). We finished the procedure, keeping the pericardial drainage in place. After 3 days of supportive care, she was discharged. There were no further events over the 2-year follow-up period.

Discussion

RF ablation causes lesion development by inducing cell death when tissue temperature exceeds 50°C; however, it can also cause steam pops when the tissue temperature is >100°C, sometimes far exceeding the catheter tip temperature. When steam explosions occur, which maybe audible as steam pops, they can cause cardiac perforation. This dangerous situation occurs more commonly in the RV than in the left ventricle because of the thin-walled structure of the RV. Externally irrigated RF ablation can cool the catheter-tissue interface, making it possible to increase power delivery and reduce coagulum formation. However, irrigated RF also causes an imbalance between tissue and catheter tip temperatures during ablation, causing difficulty in predicting steam pops. Cooper et al. found a relationship between pops and electrode temperature during atrial ablation and recommended maintaining a catheter tip temperature <40°C to prevent steam pops. However, steam pops were observed when the mean catheter tip temperature was 39°C with open irrigation and even occurred with catheter tip temperatures as low as 34°C. Yokoyama et al. demonstrated that steam pops occurred more frequently as power was increased from 30 to 50 W. Hsu et al. sug-

References


