Direct visualization of induced steam pops during radiofrequency ablation

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Introduction

Importantly, during clinical ablation procedures, the elicitation of elevated tissue temperatures may induce audible steam pops. Rapidly induced high endocardial tissue temperatures are considered to generate these events as a result of blood/tissue vaporizations. In addition, discrepancies between monitored catheter tip temperature and actual endocardial tissue temperature may be related to the unanticipated elicitation of steam pops. Ultimately, these induced tissue disruptions can have important clinical consequences. They even may result in perforations of the atrial wall and/or the release of tissue or air emboli from the affected tissues.[1]

Case report

A heart (427.3 g) isolated from a Yorkshire-Cross swine (87.2 kg) was reanimated using previously described Visible Heart® methodologies.[2] The tricuspid valve annulus was aggressively ablated using a 7 Fr Marinr ablation catheter (Medtronic Inc, Minneapolis, MN). The occurrence of a steam pop was recorded using an intracardiac endoscope (IplexFX, Olympus Corp, Tokyo, Japan) and a high-speed camera (MotionXtra N4, Olympus Corp) equipped with a borescope (88370AX, Karl Storz, Tuttlingen, Germany) (Figure 1). Of note, formation of focal microbubbles at the ablation site was observed before steam pop initiation. The application of progressive ablative energies generated and further released large quantities of explosive bubbles/tissue disruptions, which actually caused the catheter to fly away from the application site. The duration of the recorded steam pop was less than 10 ms, although submillimeter air emboli and tissue fractions were released for seconds after the initial burst (Supplemental Video 1). In this case, the endocardial damage caused by this induced "explosion" was a void 7 mm in diameter and 4 mm in depth.

KEYWORDS Radiofrequency ablation; Steam pop; High-speed visualization
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Discussion

It is important to consider that use of fluoroscopy alone as an imaging modality during such radiofrequency ablation

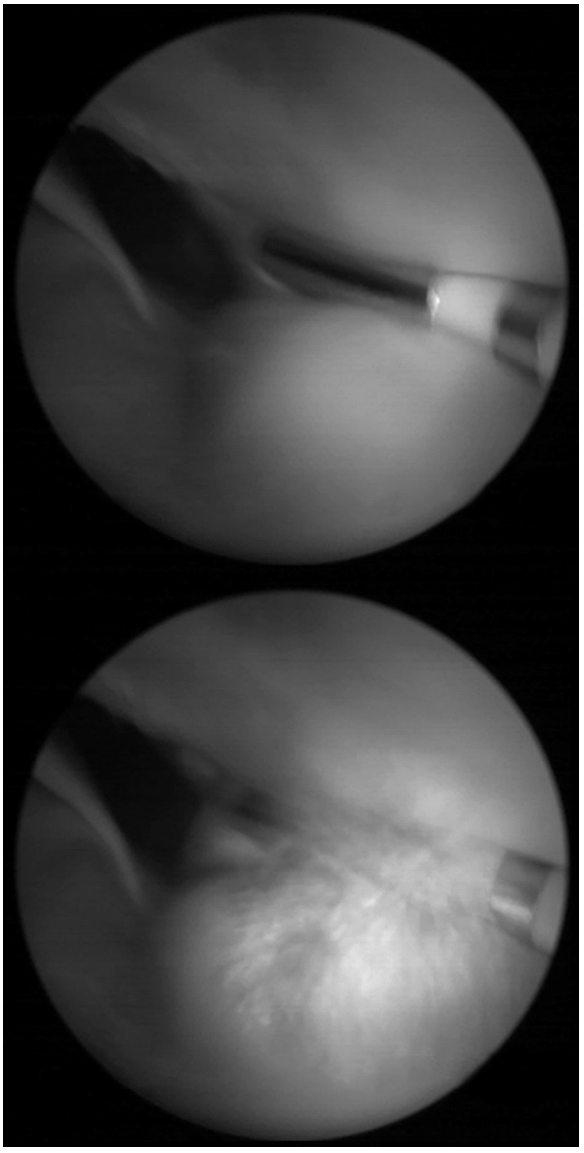

Figure 1 The explosive energy can be observed in frames 1.5 ms apart immediately prior to (Top) and during the steam pop (Bottom).

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KEY TEACHING POINTS

- Cardiac ablation–induced steam pops release air/tissue emboli that may cause myocardial infarctions or strokes. The resulting endocardial damage, if excessive, may result in perforations and/or the development of cardiac tamponade.
- Microbubbles often are released before the elicitation of steam pops. If these microbubbles could be detected, then the immediate reduction of power or halting of an ablation may reduce the occurrences of undesired steam pops.
- Identifying steam pop incidences via fluoroscopy alone may be quite challenging. Movement of the catheter during such an event, especially when there is no associated audible indicator (ie, a pop), may be misconstrued as a simple loss of wall contact.

procedures limits an operator's ability to detect relative incidences of steam pops and other associated tissue damage. In such cases, the only indication may be a visual displacement of the catheter tip and/or a rapid change in electrode temperature. Interestingly, an unintended catheter repositioning, causing a loss of wall contact, results in these same observations. During our unique visualization studies of applied radiofrequency ablations, we also noted that with early application of energies, we could observe the formation of focal microbubbles preceding the steam pop. Detection of these microbubbles may be an early indicator of undesired events. In addition, determination of catheter tip–tissue orientation may help ensure proper lesion formation while importantly minimizing the potential for inducing steam pops. In our setting, these observed tissue explosions were not always audible, suggesting that detecting their occurrence may be even more clinically challenging.[3]

The unique utilization of a high-speed visualization system and Visible Heart® methodologies allowed for novel investigation of this steam pop phenomenon at a visually perceptible rate.

Appendix

Supplementary data

Supplementary material cited in this article is available online at http://dx.doi.org/10.1016/j.hrcr.2015.02.012.

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