

Catheter Tip Force Required to Mechanically Perforate the Cardiac Free Wall

Dipen C. Shah, MD, Hendrik Lambert, PhD^{***}, Nadir Saoudi, MD^{**}, Yury Vanenkov, Beat Walpoth, MD, Nicolas Aeby^{***}, Pascale Gentil-Baron
*Hospital Cantonal de Geneve, Geneva, Switzerland, **Centre Hospitalier Princesse Grace, Monaco, ***Endosense, Geneva, Switzerland*

Introduction: Cardiac perforation with tamponade is a major complication of catheter ablation procedures. It may result from forceful manipulation over healthy tissue or radiofrequency (RF) current producing excessive intramural heating and a steam explosion venting epicardially and endocardially or forceful manipulation over weakened myocardium.

Methods: An externally irrigated ablation catheter with a sensor allowing tip electrode force measurement (sensitivity < 1 g) at 100ms intervals (TactiCath™, Endosense SA, Switzerland) was used to create right atrial (RA) free wall lesions (power 30W, irrigation 17 cc/min, 30 seconds) in anaesthetized, ventilated 50-60 kg pigs. The animals were euthanized and the heart promptly removed through a thoracotomy by sectioning the great vessels. Ex vivo, the same ablation catheter was used to manually (without RF delivery) perforate the free walls of the heart, through a long sheath (to prevent catheter buckling) and without it. In the RA, the catheter was pushed through visible ablation lesions and through healthy tissue just alongside as control. Maximum catheter tip force during perforation was analysed.

Results: Perforation was achieved at 19 sites in the RA, 15 in the left atrium (LA), 17 in the right ventricle (RV) and 14 in the left ventricle (LV). Perforation could not be achieved through the LV without the support of a long sheath because of catheter shaft buckling. Perforating tip forces (without a long sheath) through healthy tissue were lower in the RA compared to the RV (242 ± 55 g vs 310 ± 94 g, $p=0.02$). The minimum perforating force through healthy tissue for the RA, LA, RV and LV (through sheath) was 170g, 159g, 167g and 173g respectively. Perforating forces were significantly lower through RF lesions in the RA free wall than through adjacent unablated RA free wall (153 ± 62 vs 242 ± 55 g, $p < 0.005$) with a minimum perforating force of 96g.

Conclusions: Mechanical perforation with a typical ablation catheter through the healthy free walls of a pig heart required > 100g of force. Mechanical perforation can be achieved through fresh ablation lesions in the right atrial free wall by a lesser force compared to adjacent healthy tissue.