Impact of ultra-short pauses between stacked lesions with and without active esophageal cooling

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Background: Placing lesions at the same point (stacking lesions) in the left atrium during radiofrequency (RF) ablation can increase the risk of collateral injury. The use of active esophageal cooling has been shown to significantly reduce the risk of thermal injury to the esophagus, but stacking of lesions may overcome these protective effects. Longer pauses between lesions may reduce this risk, but the effect of very short pauses has not been previously quantified.
Purpose: To examine the impact of ultra-short pauses between stacked lesions with and without active esophageal cooling.
Methods: Using a computational model of the left atrium, we measured the effect of RF ablation in the left atrium on injury formation in the esophagus. Models with and without active esophageal cooling, using a dedicated esophageal cooling device, were created. Using a power of 50 W for 10 s, with up to 3 sequential lesions placed in the same location, we used the Arrhenius equation to quantify the fraction of damage (FOD) in the esophageal wall. The time between lesions was set to as short as 1 s, and results were compared to prior studies using longer pauses of up to 20 s. To account for thermal latency, measures of esophageal damage were taken both immediately after RF ablation, and again 90 s afterwards.
Results: With active cooling in place, esophageal injury was eliminated with active esophageal cooling after the first lesion placement, but reached 21% transmurality without cooling. Lesion transmurality increased after each lesion due to thermal latency, but active esophageal cooling prevented this effect when only one lesion was placed. Subsequent lesions resulted in increased esophageal injury when placed in the same location. After 3 lesions with 1 s pauses between each, esophageal injury transmurality reached 91% without cooling in place, and 22% with active cooling in place (Figure 1). In contrast, analysis of the intended lesions in the atrial wall demonstrated minimal effects from cooling (Figure 2).
Conclusions: Active esophageal cooling significantly reduces esophageal injury from RF ablation, but placing additional lesions at the same point can overcome the heat extraction capacity of a dedicated cooling device. Decreased time between lesions exacerbates this risk, with an ultra-short pause of one second posing the greatest risk.

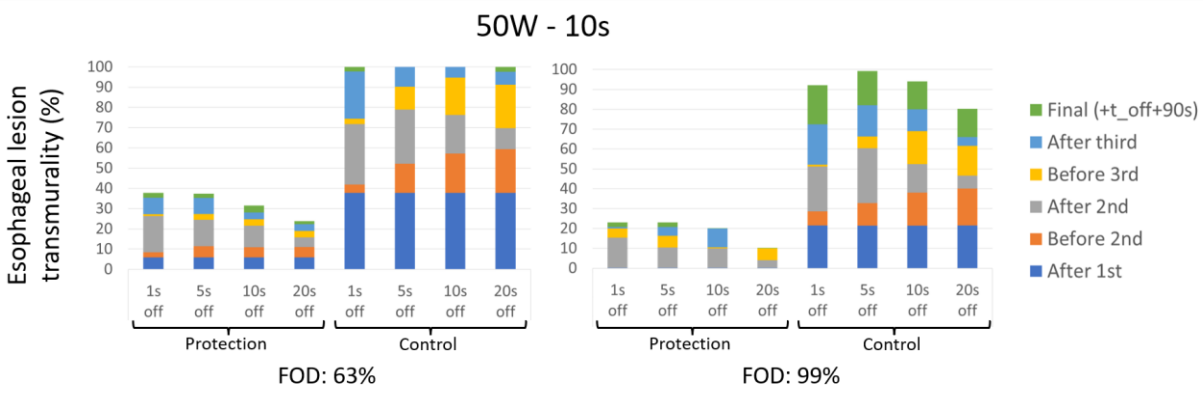

Figure 1. Esophageal injury transmurality with and without active esophageal cooling protection under varying pauses between stacked lesions.

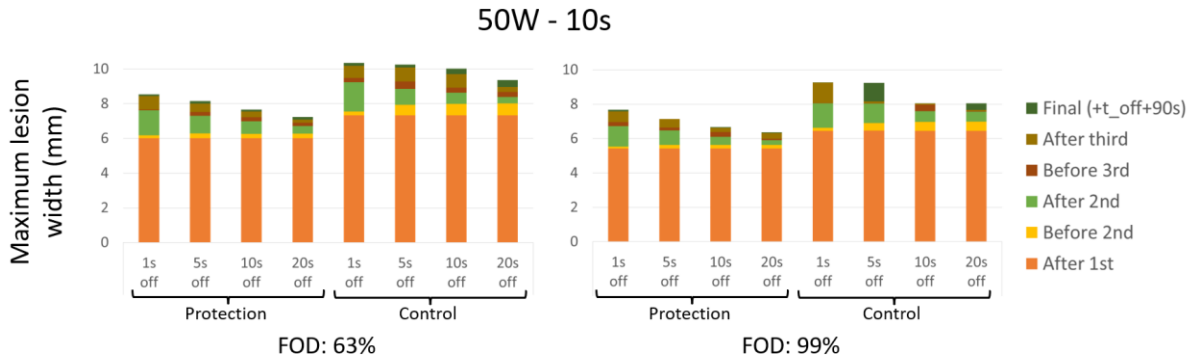

Figure 2. Atrial lesion width with and without active esophageal cooling protection under varying pauses between stacked lesions.