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UTILIZATION OF OPTICAL COHERENCE TOMOGRAPHY TO ASSESS CORONARY VESSEL CONSTRICTION AFTER ABLATION

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ABSTRACT

Epicardial ablations are being utilized as alternative techniques to the current endocardial procedures. An epicardial approach offers some advantages, especially when treating ventricular arrhythmias, e.g., those that have epicardial or transmural sites of origin. However the potential collateral damage from these applied myocardial surface ablations has not been fully explored. In order to better visualize and understand such effects on acute coronary functioning, we have employed intracoronary optical coherence tomography (OCT) of ablated cardiac tissues. Ex-vivo swine hearts were reanimated utilizing Visible Heart® Laboratories methodologies, then the midsection of the LAD was anatomically characterized via OCT before and after an applied epicardial ablation: including using irreversible electroporation (IRE), and radiofrequency ablation (RF). Post-ablation OCT scans revealed detectable coronary diameter reductions stemming from applied adjacent epicardial ablations. These initial results demonstrate a need for further explorations to better understand and thus minimize collateral damage during epicardial ablations.

Keywords: Ablation, OCT, Coronaries, RF, IRE, electroporation

1. INTRODUCTION

Epicardial ablations for the treatments of ventricular arrhythmias via percutaneous pericardial access is becoming more common, particularly for individuals that require additional ablation procedures [1]. Damage to the coronary arteries are important concerns for any applied epicardial ablation. To date, characterizations of the effects of various ablative energies applied to the coronaries have been limited to evaluation of lesions created by epicardial RF [2]. Therefore, further exploration is needed to determine more transient effects like induced coronary restrictions (which can cause angina or more severe events). Newly developed ablation technologies also need to be evaluated to determine their potentials for inducing collateral damage. For example, in transcatheter ablative treatment for atrial fibrillation, pulmonary vein stenosis has been observed as a possible chronic side effect of applied RF, whereas similar electroporation therapies has been shown to not have these same effects [3].

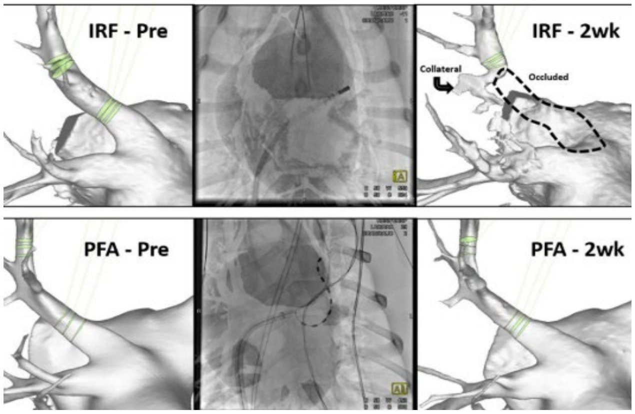

Figure 1: Vascular stenosis resulting from RF and electroporation (PFA) 2 weeks after ablation [3]

Acute effects on the coronary arteries relative to the multitude of ablation modalities been utilized today, have yet to be characterized. Here we investigated the utility of employing OCT to provide a unique way to monitor potential coronary damage during an applied ablation procedure.

Optical Coherence Tomography (OCT) is an intraprocedural tool that has gained wide utilizations in the coronary intervention space; i.e., to help guide percutaneous coronary interventions (PCIs) [4]. OCT uses a guidewire-fed catheter system that, once inserted into a coronary artery, uses a laser to image the inner lumen space. OCT can provide physicians insight on plaque deposition, stent apposition, lumen dissections and/or vessel diameters. In this study, we aimed to extend the use of OCT by utilizing its abilities to measure lumen diameters within reanimated swine hearts so to measure the potential collateral effects of ablations applied near the coronary arteries.

2. MATERIALS AND METHODS

A swine heart was reanimated using the Visible Heart® methodologies [5]. Once reanimated, a 0.035” guidewire was advanced up to the aortic valve to allow for the advancement of a 7F coronary guide catheter (Medtronic, Minneapolis, MN). The guide catheter was then used to gain access the LCA ostium to allow for the advancement of a 0.014” coronary guidewire down the LAD. The OCT catheter (ABBOTT, Chicago, IL) was then tracked along the guidewire up to the most distal portion of the LAD. A baseline OCT scan was performed to characterize the lumen prior to ablations. All scans performed in this study consisted of 540 cross-sectional slices along a 54mm scanning length with a penetration radius of 5mm.

Before performing any ablations, the OCT catheter was retracted back into the coronary guide catheter within the aorta to avoid damaging the catheter. Note, the 0.014” guidewire remained in place during the applied ablations to allow for easier advancements of the OCT catheter immediately post-ablation.

With the OCT catheter safely retracted, up to three sites along the LAD could be chosen for the administered ablations. The ablation modality was randomly assigned, and the ablations were typically performed in order of most distal to proximal. For the irreversible electroporation ablations, two NanoKnife (Angiodynamics, Latham, NY) electrode needles were placed so that the LAD would be between them, with each electrode 5mm from either side of the artery, as seen in **Figure 2**.

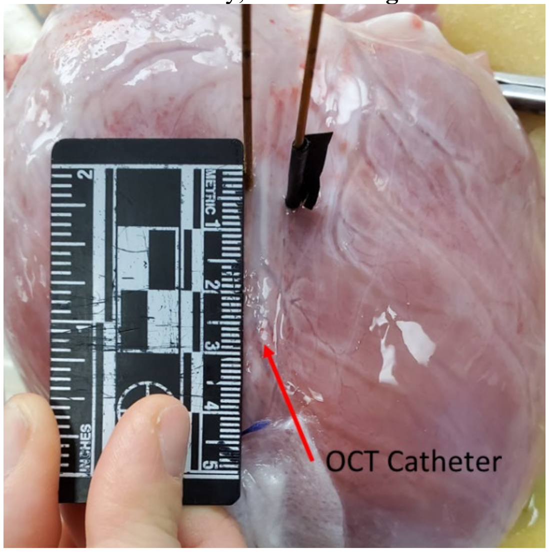

Figure 2:Swine heart with IRE needles on either side of LAD. OCT catheter is visible along LAD (note, this IRE approach was utilized for experimental use only)

70 monophasic 90µs pulse-width pulses of 500V and 700V were delivered at site 1 and 2 respectively. For the radiofrequency ablation, an Atakr (Medtronic, MN) RF generator was used. A 4mm point electrode was used to deliver the RF energy. Immediately following each ablation, the OCT catheter was advanced and a vascular tomography image was acquired.

Scans obtained from the reanimated hearts were post processed using the OPTIS software integrated with the OCT scanner. This allowed for the precise marking of each applied ablation within the scans. Anatomical landmarks (e.g., bifurcations) were used to define reference points to measure the proximal distances of the ablation locations.

3. RESULTS

In these pilot studies, significant reductions in both areas and mean diameters of the LAD could be observed following some of the applied ablation. Note, OCT analyses presented no other regions of damage to the inner lumens of the coronaries.

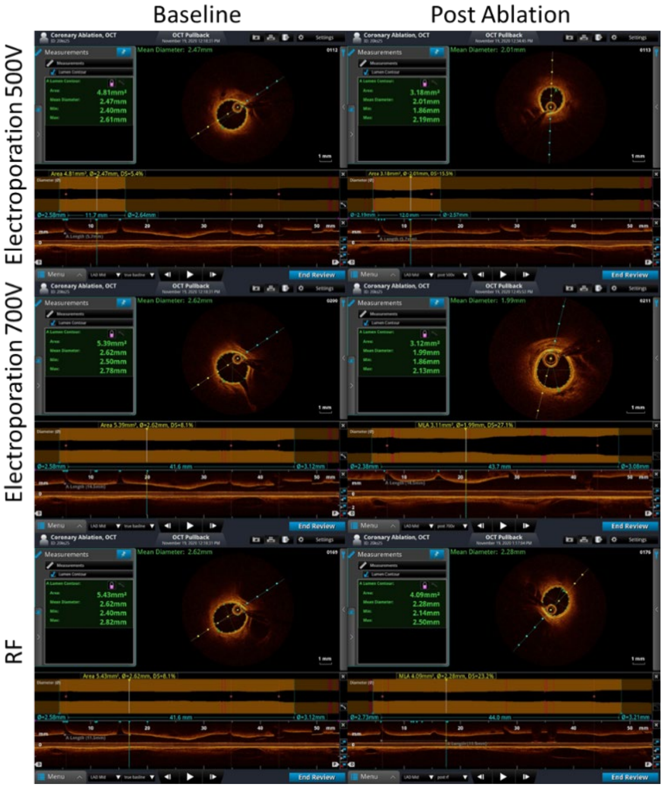

Figure 3:OCT image and analysis pre and post ablations.

Figure 3 provides an example of OCT imaging of the anatomical LAD segment that was of interest. The left column is the OCT image prior to each ablation while the right column is the image immediately following an applied ablation modality, specified on each row. One can process a given image to calculate the average diameters and the cross-sectional areas of the vessel at specified locations.

Example results from the analyses of the OCT data are summarized in **Table 1** below.

Ablation Modality	**% Area reduction**	**% Diameter Reduction**
IRE 500V	33.9	18.6
IRE 700V	42.1	24.0
RF 30W	24.7	13.0

Table 1: Area and diameter reduction following ablation. All values are percentage change from pre-ablation image

As compared to baseline in this example, the 700V IRE ablation resulted in the greatest reductions in coronary areas and diameters (42.1% and 24%) while this given RF ablation induced more modest reductions in areas and diameters, of 24.7% and 13% respectively.

4. CONCLUSION

Our preliminary data suggests that immediately following an applied ablation procedure, epicardial coronary arteries may be susceptible to significant contracture events. Specifically, applied ablations immediately adjacent to the LAD, may induce acute reductions in focal vessel diameters as assessed with OCT. Follow up studies are underway looking at a variety of applied ablation modalities and energies as well as their induced chronic effects. This study approach can be utilized to provide critical insights to guide the future development of cardiac ablation therapies and/or for clinical preprocedural planning, so to minimize impacts on associated collateral damage on coronary vessel functioning.

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