Monitoring and Guidance of Ablation Therapy with Optics

Christine P. Hendon
Associate Professor
Department of Electrical Engineering
Columbia University

Monday, 2/22, 9:55 am
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LECTURE ABSTRACT

The research goals of the Structure-Function Imaging Laboratory are to develop platform optical imaging systems to enable structure-function analysis of biological organ systems. Towards this goal, we develop optical coherence tomography (OCT) and near infrared spectroscopy (NIRS) systems and automated processing tools to correlate tissue microstructure to electrical conduction and mechanical contraction. Within this talk, I will highlight our effort towards monitoring and guidance of radiofrequency ablation therapy with optical technologies. There is typically an underlying substrate due to remodeling with the development of scar tissue or fibrosis that is the cause of the abnormalities in conduction patterns. Therefore, better understanding how the microstructure of the myocardium influences electrical conduction will greatly inform these therapeutic procedures. We propose to use optical imaging and spectroscopy as a means to monitor and guide radiofrequency ablation treatment of cardiac arrhythmias, which will directly interrogate the tissue for characterization in real time. I will present analysis of OCT and NIRS optical signals, metrics to extract information on energy delivery, remodeling and composition, and fiber orientations within human hearts. In addition, I will discuss our technical advances to enable real time monitoring of ablation therapy *in vivo*, including novel optical probes integrated within ablation catheters, extraction of polarization contrast to assess fibrosis, and the use of compressive sensing to reduce the burden of data and extract mechanical motion. We have shown that NIRS integrated with an RFA catheter is capable of extracting tissue information as deep as 4mm. NIRS can also assess tissue-catheter contact with high accuracy and discriminate ablated from unablated tissue. Importantly, gaps can be readily identified and maps of lesion thickness calculated. OCT detects distinguishing features between regions of myocardium within the left atrium and regions of only venous endothelium, media, and adventitia - that is, regions of transmural connective tissues - inside the pulmonary veins. Detailed tissue characteristics such as endocardial thickness, myointimal thickening, and fibrosis could also be determined. Together, this will provide the foundation for optical imaging guidance providing information on tissue architecture to improve ablation outcomes by enabling targeted ablation based on tissue structure.

SPEAKER BIOSKETCH

Christine received the B.S. degree from Massachusetts Institute of Technology in Electrical Engineering and Computer Science in 2004, along with the M.S. and Ph.D. degrees from Case Western Reserve University in Biomedical Engineering in 2007 and 2010, respectively. She completed her postdoctoral fellowship at the Wellman Center for Photomedicine at Massachusetts General Hospital and Harvard Medical School in 2012. She joined Columbia University in 2012. She teaches courses on image processing and optical systems and leads the Structure Function Imaging Laboratory. Her work is currently funded by the National Science Foundation and the National Institute of Health, and she has received recognition for her work from Forbes' 30 under 30 in Science and Healthcare (2012), MIT Technology Review's 35 under 35 Innovators (2013), NIH New Innovator Award (2014), NSF CAREER Award (2015), and 2017 Presidential Early Career Award in Science and Engineering. Christine is a fellow of SPIE, OSA, and AIMBE.