A colonoscope-compatible photoacoustic-ultrasound imaging catheter for characterizing intestinal fibrosis in Crohn's disease

Yunhao Zhu, Linyu Ni, Laura A. Johnson, Kathryn A. Eaton, Jonathan Rubin, Xueding Wang, Peter D.R. Higgins and Guan Xu, University of Michigan, Ann Arbor, MI, USA

Background, Motivation and Objective

The chronic bowel damage seen in Crohn's disease (CD) is characterized by obstructing intestinal strictures due to a mixture of inflammation, fibrosis and muscular hypertrophy. The largely acute inflammatory strictures can be treated by anti-inflammatory therapy using corticosteroids, while chronic fibromuscular strictures are irreversible and require surgical resection. Timely CD management would greatly benefit from accurate assessment of the presence and extent of fibrosis in intestinal strictures to avoid adverse steroid effects.

Statement of Contribution/Methods

A photoacoustic-ultrasound (PA-US) imaging catheter has been developed using all medical grade components, including an ultrasound catheter array (Acunav 8F, Siemens), a fiber optic and a customized balloon catheter (Nordson Medical), as shown in Fig. 1. When collapsed, the PA-US imaging catheter can fit into the instrument channel of a colonoscope (Olympus CF-10L). A Verasonics US platform enables the real-time and parallel PA and US imaging. The catheter probe will be positioned at the intestinal stricture lumen with the guidance of the camera in the colonoscope and afterward inflated using water for the acoustic coupling. 750 and 1310 nm illumination will be used for PA imaging of hemoglobin and collagen, which are the characteristic components of inflammatory and fibrotic tissues, respectively. The performance of the imaging probe has been examined in a phantom study. The performance of the imaging probe in characterizing intestinal strictures in trinitrobenzene sulfonic acid (TNBS) treated rats *ex vivo* and rabbits *in vivo* is under investigation.

Results/Discussion

The probe has demonstrated axial and lateral resolutions of 340 and 420 microns, respectively, at PA imaging mode. Similar to the conclusion in our previous studies, PA imaging of inflammatory intestinal strictures have demonstrated higher hemoglobin content compared to the normal intestines. Fibrotic intestinal strictures possess more collagen content compared to the inflammatory ones. Statistical analysis and pathological validation with the animal models will be performed as more data are acquired in the near future.



Fig. 1. The proposed PA-US balloon catheter. (a) and (b) are the collapsed and inflated status of the balloon catheter. (c) and (d) are the US and PA (acquired at 1310 nm) images of a piece of *ex vivo* fibrotic intestinal stricture tissue. Strong PA signals correlated to the collagen content are shown.