CIMIT MEETING SUMMARY 7/10/01

The meeting was the first in a series of three tutorials on "Optical Diagnostics". Brett Bouma, PhD described some of the motivations for applying optical techniques to medical diagnostics; they are minimally invasive, safe (non-ionizing, non-destructive), offer high selectivity or contrast and have high resolution (micron scale). The technology developed by the telecommunications industry can often be used in medical applications, providing commercial optical components which offers lower-cost than custom components or systems. Throughout the series, Optical Coherence Tomography (OCT) will be used as an example of both the technology and the development process.

The technology development process the OCT group uses can be broken down into several steps. Definition of the problem is followed by invention of a solution and prototype development. In-vitro studies are followed by further technology development to make a clinically-viable system. Preliminary clinical studies are used to determine the clinical viability of the prototype for detecting the disease process of interest. These studies are then followed by clinical validation studies to determine the sensitivity and specificity of the diagnostic results. Finally, if these hurdles are successfully passed, the technology can be transferred to another entity for commercialization. All these steps must occur in a multidisciplinary program, in which physicians and technologists cooperate in goal-setting, preliminary testing and clinical trials.

OCT was described from the viewpoint of both the technology and the clinical applications. OCT is an optical ranging technique which is analogous to ultrasound imaging, but offers much higher resolution. It obtains cross-sectional images using reflected light; typical operating parameters are about 10-micron depth resolution and an ability to penetrate 1-3 mm into tissue, the penetration depth being determined by tissue scattering or absorption. The MGH OCT system uses 1.3 micron wavelength sources to take advantage of the relatively low tissue absorption and scattering in this spectral region. Much of the equipment uses fiberoptic technology, making it well suited to delivery through endoscopes.

The initial clinical application of OCT, developed at MIT in 1991, was to ophthalmology and took advantage of the transparency of the eye to image the retina in depth. In 1997 the MGH-Wellman group completed integration of a portable OCT system intended for clinical studies and capable of imaging at 8 frames per second. Although pilot studies in a number of clinical disciplines were conducted, the effort is now focused on cardiology and gastroenterology. The GI studies involve Barrett's esophagus and esophageal cancer; both have progressed to human subjects. Barrett's can progress to adenocarcinoma and is not visible by endoscopy. The system used for Barrett's allows prescreening for biopsy and may be able to serve as a stand-alone diagnostic. In a prospective study a sensitivity of 100 % and a specificity of 92 % was achieved.

The cardiology effort focus on the detection of vulnerable plaque in coronary arteries, which is characterized by a thin cap, a high lipid content and abundant macrophages. There is currently no reliable method of detecting vulnerable plaque, which can lead to

MI and death. An OCT catheter, based on an approved IVUS catheter was developed and tested in cadaver arteries and animal models. In order to obtain images, a saline flush lasting 2-3 seconds is used to clear the artery of the optically-absorbing blood. In a pilot study involving 13 patients high-quality images were obtained in all three arteries and the layers of the arteries, as well as implanted metal stents, could be resolved. A variety of pathologies were imaged. A new human study, with 30 patients planned, will focus on post MI patients in order to see if vulnerable plaque can be detected.

Thomas F. Deutsch 7/12/01