Quantitative Imaging of Tumor Vascularity to Explore Changes Associated with Colon Carcinogenesis

Sarah Ruderman* [1], Mariano Gonzalez-Haba[2], Urszula Dougherty[2], Jana Zujovic[1], Jeremy Rogers[1], Andrew Gomes[1], Thrasyvoulos Pappas[1], Vani Konda[2], and Vadim Backman[1]
(1) Northwestern University, Evanston, IL, 60208
(2) University of Chicago Medical Center, Chicago, IL

Optical techniques, because of their noninvasive nature and the distinct scattering and absorption of biological markers (i.e. hemoglobin), are some of the most popular methods used to assess carcinogenesis. Angiogenesis, the growth of new blood vessels, is one of the hallmarks of cancer. In-vivo imaging techniques can provide insight into vessel changes during carcinogenesis with the identification and quantification of vascular parameters. The aim of this study was to differentiate vessel patterns between normal colonic mucosa (n=5 mice) and the well-established azoxymethane (AOM) model of experimentally induced colonic tumors (n=9 mice). Confocal laser endomicroscopy (CLE) (Mauna Kea Technologies, Paris) allowed real time visualization of capillaries in mice 22-24 weeks after AOM treatment. CLE videos of tumors and random normal mucosa were reviewed and still frames selected (n=167 images) for analysis. By visual assessment, vessels of normal mucosa appeared to encircle crypts in the same focal plane with relatively straight vessels of equal caliber. In contrast, vasculature from tumors appeared irregular and ectatic, with vessels projecting in and out of the focal plane. These observations were translated into a quantitative similarity index with multi-scale decomposition, a linear decomposition into several subbands, localized in scale and orientation. Mean, variance, horizontal correlation, and vertical correlation are obtained within each subband, as well as the correlation across each pair of subbands to form one feature vector for each image. Similarity Index (SI), defined as the distance between features across images, can be used for classification of images. A small SI indicates more similarity with respect to the spatial distribution and structural elements (i.e. a normal, honeycomb-like network of vessels). Conversely, a larger SI value indicates less similarity between images (i.e. potential disruption of the normal vessel network). This algorithm can be automated to characterize blood vessel structures and may be more indicative of angiogenesis associated with neoplasia than traditional measures of vessel diameter and density. In a diagnostic capacity, cancer-induced angiogenesis would manifest as an increased local hemoglobin concentration. Elucidating the microvascular changes during tumorigenesis is central for designing novel optical technologies for early detection or monitoring of cancer and other diseases.