SEEING EARLY CANCER IN A NEW LIGHT WITH HYPERSPECTRAL ENDOSCOPY

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Hyperspectral imaging represents a new frontier in medical physics that enhances colour vision and enables measurement of local concentrations of key biomarkers. For example, the distinct spectral properties of oxy- and deoxy-haemoglobin can be exploited to infer local blood concentration and oxygenation (1). The dynamic cellular ecosystem of a growing tumour mass requires a vascular network to obtain oxygen and nutrients, as well as to remove metabolic waste products. Early in their development, tumours stimulate new blood vessel growth to meet this need, leading to marked changes in vascular structures in the early evolution of cancer that can be explored for early detection (2).

Oesophageal cancer is a deadly disease, with a 5-year survival rate <20%. Fortunately, there is an opportunity to catch it early because many patients suffer from Barrett's, a condition that increases oesophageal cancer risk. Patients with Barrett's undergo endoscopic surveillance every 3-5 years to look for dysplasia (pre-cancerous change), which can be removed with local resection (3). Unfortunately, current endoscopy simply replicates our vision and poor colour contrast means the current surveillance protocol suffers miss rates of up to 50% (4). Early vascular changes in dysplasia are examined clinically using narrow-band imaging, which meets the clinical standards needed to target biopsies but is a purely qualitative assessment. We therefore hypothesized that hyperspectral imaging could further improve sensitivity by providing quantitative imaging biomarkers leading to contrast enhancement for the earliest lesions.

The wide range of image distortions experienced during clinical endoscopy make accurate hyperspectral imaging difficult. To address this challenge, we have explored a range of innovations in biomedical optics to enable hyperspectral measurements in a clinical setting, including: direct spectroscopy measurements *in situ* co-registered with histopathology (5), combined line-scan hyperspectral and white light imaging to correct for image distortions computationally (6,7), the optimization (8,9) and application (10) of spectrally resolved detector arrays for snapshot imaging, and applications of machine learning for disease classification and visualisation (11). Building from findings in our first-in-human clinical trials (5,7,10), we are convinced of the power that hyperspectral endoscopy can bring to disease diagnostics and are currently creating new ways to sample hyperspectral information at high speed and low cost, while maximizing optical throughput and data quality.

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