ADVANCES IN GERD

Current Developments in the Management of Acid-Related GI Disorders

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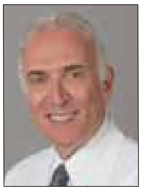
Spectroscopy for Esophageal Diseases



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G&H What is the role of spectroscopy in relation to esophageal diseases?

JVD Spectroscopy is a powerful diagnostic tool that exploits properties of light beyond the limits of human vision, and can also harness properties of energy in the electromagnetic spectrum outside the confines of visible light. Using spectroscopy, some esophageal diseases may be detected at stages much earlier than would otherwise be noticed when using conventional methods, such as standard endoscopy. For most applications, spectroscopic tools use high-speed computers to provide quantitative information on the data derived from the interactions between light and tissue. In this way, the data obtained by spectroscopy may be objectively assessed, compared, and contrasted to provide meaningful clinical information.

G&H What are the most common esophageal indications for spectroscopy?

JVD More than 85% of all cancers originate in the surface epithelium of the organ in which they occur. When diagnosed in the later stages, patients with esophageal cancer have a poor prognosis, and most die of the disease. Some patients with symptoms of esophageal disease, such as heartburn or gastroesophageal reflux disease, may ultimately be at risk for esophageal cancer. Other patients with no appreciable symptoms of esophageal disease may also be at risk for esophageal cancer but do not come to medical attention until the later stages of the disease. Early-stage disease is readily treatable but very difficult to detect. Before they become invasive, early cancer cells demonstrate an altered subcellular architecture. Some of these changes include enlarged nuclei, more nuclear volume per unit area (sometimes referred to as nuclear crowding), and hyperchromicity (ie, staining abnormally dark with contrast dye). Because an important goal of endoscopy is to identify patients at risk for esophageal cancer, and because conventional endoscopy alone cannot detect these prognostic subcellular changes, using spectroscopic tools as an adjunct to standard endoscopy has the potential to improve its diagnostic capability.

> Spectroscopy has the virtue of being completely objective based entirely on the physical properties of light, both visible and invisible.

In addition to esophageal disease, spectroscopy has been used in the field of gastroenterology to discriminate between benign and precancerous polyps during colonoscopy; to detect so-called flat dysplasia in the colon, especially in patients with chronic inflammatory bowel disease; and to diagnose patients with pancreatic cancer (ie, ductal adenocarcinoma) by virtue of a field effect associated with the disease.

G&H What are the various types of spectroscopy available for examining the esophagus?

JVD When used in the context of detecting subtle changes in epithelial tissue, spectroscopy is a general term that includes the various methods used to detect these changes. Each method has the potential to contribute some diagnostic information about the tissue. For example, one of the earliest forms of spectroscopy used in gastroenterology was fluorescence spectroscopy. Using this method, a patient's endogenous cellular biochemistry or naturally occurring fluorophores (autofluorescence) could be used to infer diagnostic information when interacting with light. Alternatively, an exogenous dye could be administered to the patient to increase the diagnostic yield. Light-scattering spectroscopy (LSS) utilizes the interaction of light with the cellular and subcellular matrices of an individual to distinguish healthy from diseased processes. Elastic LSS, in which there is no change in wavelength, has been used successfully in gastroenterology in detecting high-grade dysplasia in patients with Barrett esophagus as well as in the stomach and colon. A very simple method of spectroscopy is reflectance spectroscopy, which quantitatively measures the color and intensity of reflected light. One example that is often used to demonstrate reflectance spectroscopy is oxygenated hemoglobin, which, when illuminated with white light, absorbs much of the blue light and reflects back the red light, giving its characteristic color. Alternatively, deoxygenated hemoglobin absorbs a higher degree of red light and, thus, appears bluer when illuminated with white light. Rudimentary methods to alter the wavelength of light emission during endoscopy exist in the form of narrow-band imaging and flexible spectral imaging color enhancement.

G&H Can you describe the development of Raman spectroscopy?

JVD Raman spectroscopy was named after its inventor, Sir Chandrasekhara Venkata Raman, who, in 1928, observed a change in the wavelength of light that occurs when an incident light beam is scattered or deflected by molecules inherent in the target of the incident light. This form of spectroscopy measures vibrational and rotational aspects of the target molecules, thus providing insight into their molecular composition. Additionally, Raman spectroscopy has the potential to discriminate between proteins, nucleic acids, and lipids, and, therefore, would be extremely useful in clinical diagnoses. Although a potentially powerful clinical tool, Raman spectroscopy is limited by the relative weakness of the signal when compared with other forms of spectroscopy used for clinical purposes.

G&H What are the main benefits and limitations of spectroscopy?

JVD The main benefit of spectroscopy is that the information it derives can be collected and assessed in real time, obviating the need to remove tissue (ie, biopsy) with its attendant risks and costs. In fact, a reliable spectroscopic diagnosis would eliminate the need for taking biopsies (which can result in sampling error and be traumatic for the patient), processing biopsies, placing the specimen in a fixative, embedding it in paraffin, cutting it on a microtome, and having it analyzed by a specialist (eg, pathologist) at a future time and in another location. Pathology has its own limitations as well, including a lack of perfect sensitivity and specificity and suffering from interobserver variation. Spectroscopy has the virtue of being completely objective based entirely on the physical properties of light, both visible and invisible. Finally, because the results are not dependent on image interpretation, no advanced training is required.

> It may be that a combination of spectroscopic techniques will be required to detect dysplasia in patients with Barrett esophagus.

The limitations of this tool are difficult to assess because spectroscopy, as it pertains to evaluating patients with esophageal disease, is primarily a research tool.

G&H Have any studies examined the cost-effectiveness of spectroscopy?

JVD Any examination of cost-effectiveness in evaluating patients with esophageal disease will need to wait until spectroscopic hardware and software are mass-produced for a commercial market. It is intuitive that eliminating the less-than-perfect and costly methods of tissue removal (ie, biopsy), processing, and interpretation (ie, pathology) could favor spectroscopy, but only if its effectiveness were equal or superior to pathology and its costs were lower.

G&H What are the priorities of research in this field?

JVD Ongoing research in spectroscopy has focused on expanding the indications for its use. Another area of research is arriving at the most sensitive and specific type of spectroscopy for each clinical indication. It may be that a combination of spectroscopic techniques will be required to detect dysplasia in patients with Barrett esophagus. Further research is needed.

Dr Van Dam has no relevant conflicts of interest to disclose.

Suggested Reading

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