Detection and Localization of Early Lung Cancer by Imaging Techniques*

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LIFE = lung imaging fluorescence endoscope

The detection and localization of lung cancer in the carcinoma in situ or the microinvasive stage offers an excellent prognosis for patients. However, these, small, early lung cancers are difficult to detect and localize even with conventional fiberoptic bronchoscopy. Several attempts have been made in the past to enhance the detection of early lung cancer by using fluorescent tumor markers such as hematoporphyrin derivatives.1-7 A new method to image early lung cancer without the use of investigative drugs has been developed. This new procedure exploits spectral differences of the autofluorescence of normal and cancerous tissue. Fluorescence images at two (or more) characteristic spectral bands are amplified and captured by a sensitive image-intensified camera. These images are then digitized using a mathematical transformation and converted into a pseudo image that clearly delineates the cancerous area when displayed on a color video monitor.

In vitro spectroscopy was performed using an optical multichannel analyzer. A helium-cadmium laser (442-nm wavelength) at 10 mW power was used for excitation. An example of the autofluorescence spectra induced by a helium-cadmium laser in a patient with carcinoma in situ is shown in Figure 1. The spectral differences can be used to image early lung cancers without fluorescent drugs.

Figure 2 is a schematic diagram of the experimental prototype used to test various imaging concepts in vivo in patients suspected of having early lung cancer. The system consisted of an image-intensified CID camera with a filter slide attached to the eyepiece of a conventional fiberoptic bronchoscope (Olympus BF10). A helium-cadmium laser (442 nm wavelength) was used as the excitation light to induce tissue autofluorescence. Up to three images could be taken sequentially in the same area of the bronchial tree with different filters. The images were captured by the imaging board of an imaging system* and subsequently displayed on a video monitor.

The key to imaging early lung cancer with this technique is to obtain simultaneously (or sequentially) two or more precisely matched and aligned images of tissue autofluorescence at different spectral bands. For a practical device, real time imaging will be required. An imaging device was therefore designed that can provide real time imaging in an inexpensive way. It incorporates the principle of ratioing which can eliminate the effects of distance and angle of the illuminating light as well as tissue reflective properties.6 This device, the lung imaging fluorescence endoscope (LIFE), employs two image intensified CCD cameras as well as a color video camera. The white light illumination cycle of a conventional fiberoptic bronchoscope is time shared with laser illumination of 442 nm. A xenon light source is used to obtain color images of the lung using the video camera. The images can

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FIGURE 1. In vitro autofluorescence spectra of normal bronchus and carcinoma in situ induced by a helium-cadmium laser (442 nm wavelength, 17 mW).
be processed in real time and the pseudo image displayed simultaneously on the video monitor as the color image. Figure 3 shows an example of this approach where the spectral differences between the fluorescence of normal bronchial tissues and carcinoma in situ are presented as changes in hue and saturation in a color video image. A device such as LIFE will be very useful in the detection and localization of early lung cancer, in the staging of the extent of endobronchial spread of bronchial cancers, and as an educational tool to train bronchoscopists to recognize subtle but potentially detectable changes in a standard bronchoscopic examination.

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