Photography Through the Fiber Gastroscope

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A permanent record is highly desirable in any endeavor requiring visual interpretation. Many attempts in the past to obtain photographs through the conventional lens gastroscope yielded low-contrast pictures of poor definition because of the poor light transmission. The electronic flash equipment introduced by the French gave still photographs in color of high quality. Some attempt at movie photography using pulsed synchronized high voltage illumination had been made just prior to the introduction of the fibergastroscope (Fiberscope*). The Japanese investigators concerned with endoscopic photography developed the gastrocamera, a subminiature camera which is swallowed and takes multiple blind photographs of the gastric lumen. The principal objections to all these methods are the complexity of the accessory photographic apparatus, the potential hazard of high voltages employed in both electronic-flash and pulsed-light techniques, and the poor quality of the movies obtained.

We were gratified to find that the light transmission characteristics of the Fiberscope[1] were such that even moving pictures in color could be easily obtained.

PRINCIPLES OF ENDOSCOPIC PHOTOGRAPHY

Essentially, an object (the mucosa) has to be illuminated, the image transmitted through the instrument, and recorded on photographic film. This image is perceived by the viewer after projection onto a plane surface.

The factors involved in obtaining good pictures are (1) adequate light,

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Two teaching films have been deposited with the secretary of the American Society for Gastrointestinal Endoscopy—one 16-mm. with a magnetic sound track showing the technic of endoscopy and some representative lesions, and an 8-mm. movie without sound showing normal and abnormal findings in the stomach, duodenum, and jejunum.

The author is indebted to John Hett of American Cystoscope Makers, for helping us work out some of the practical details of the photography. Dr. John Balint took some of the sequences shown in the movies.

*American Cystoscope Makers, Inc., New York, N. Y.

(2) resolution of the image, (3) definition of the image, which involves contrast, (4) good color rendition, and (5) perception and acceptability by the viewers. After meeting the basic requirements of adequate illumination and light transmission which, in the Fiberscope, is 2½ times better than the conventional gastroscopes which use the same light source, the remaining requirements still have to be met.

THE FIBERSCOPE

Figure 1 shows a schematic representation of the Fiberscope. A fiber bundle can accept an image which is projected onto the plane of the distal end of the fiber bundle (Plane A) only. This is transmitted to the other end of the bundle (Plane B), and can be perceived only at that plane, where the image is transmitted to the surface of the film (Plane C) or to the eye. Assuming no distortion by the focusing Lenses a, b, and c, which will be dealt with shortly, the next essential to consider is the effect of the construction of the fiber bundle on resolution of the image.

A fiber bundle is composed of a large number of glass-coated optical fibers (referred to as coating and core) arranged so that the fibers are in the same permanent spatial orientation at each end. Each fiber is about 11 μ in diameter with a core of 9 μ and a coating of 1 μ. Only the core transmits light, and the individual cores are thus separated by about 2 μ of coating which does not transmit light. There is thus only about 67% of the cross-sectional area of each fiber available for light (and consequently image) transmission. In the Fiberscope, a bundle of about ¼-inch diameter contains about 200,000 fibers, each fiber transmitting only a spot of light and not an image. The composite image as seen at the other end of the bundle is thus made up of 200,000 spots of light which the viewer then fuses into a picture which is comparable to the half-tone illustration, the type usually

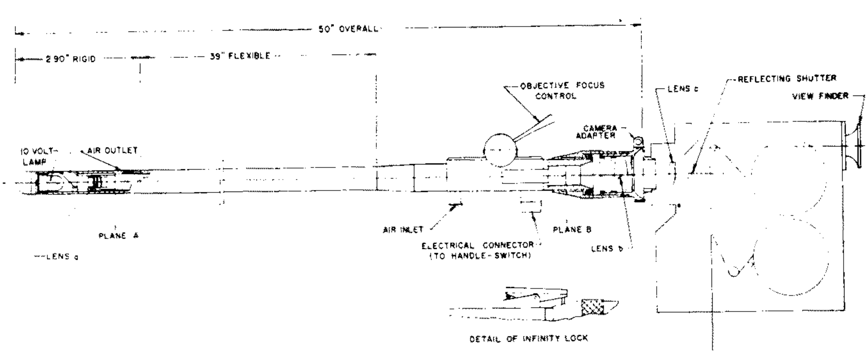

Fig. 1. Diagram of Fiberscope. Planes involved in obtaining a photographic image.

used to reproduce photographs in books and newspapers. Resolution of the image thus depends on the fiber size and correct alignment of the fibers. With the fiber size now in use, objects having a dimension of over 4 μ will enter the picture. The alignment of the fibers is such that the fiber bundles now in use will resolve 40 lines per millimeter as compared to a resolution of 60 lines per millimeter by the conventional gastroscope using lenses. The fragmentation of the image into 200,000 spots of light (fibers) accounts for the grain. Resolution can be somewhat improved by moving or vibrating the image so that more of the details enter the fiber bundle. Vibration allows some of the details to move back and forth rapidly from one fiber field to another thus eliminating the condition in which much of the image impinges on nonconducting coating or the packing space between fibers. If this movement occupies less than 0.1 sec., the eye will not perceive the change but only perceive an improvement in resolution. Single, still photographs through the Fiberscope are inferior to the image obtained by direct viewing or by movies because, with movement of the object frozen by the still (single-picture) photography, about ⅓ of the image is not conducted. Such photographs therefore appear much more "grainy" than movies.

Definition

The term "definition" is used somewhat differently from "resolution," which is dependent on the bundle composition as described above, and refers principally to focusing correctly, thus making the best use of the optical characteristics of the fiber bundle.

Referring again to Fig. 1, there are 3 planes on which the image has to be sharply focused by Lenses A, B, and C. Lens A is controllable from the proximal end of the instrument (Fig. 1), and needs to be adjusted for the distance of the object from the head of the instrument. Perception (visual or photographic) of the composite image on the proximal end of the bundle is controlled by focus Lens B which magnifies the image 10 times and is adjusted by turning the lens in and out. By focusing on the proximal end of the bundle, its fiber structure is made most evident; this component of "grain" is unavoidable in obtaining the sharpest definition of the image. Normally, if the observer is interested in the image itself, especially a moving image, the impression of "graininess" is mentally suppressed, a process which is repeated when viewing motion pictures, but less easily when viewing still photographs.

This process of (subconscious) image selection may be reproduced by looking through the Fiberscope at an imageless field (plain white surface) where the grain or bundle structure is evident and then moving across a line of print which one wants to read. The object of interest then passes to the psychologically positive image (the print), and the grain or bundle structure becomes much less intrusive and may disappear entirely from conscious perception.

The third plane on which accurate focusing becomes important is the film (Plane C). To this end Lenses B and C have to be coupled accurately, Lens C being the camera lens. Although Lenses B and C may be coupled at any compatible distance, it was found best to set both at infinity, so that the correct setting would not have to be determined empirically at each use. The Fiberscope can be modified (Fig. 1) so that the infinity setting (almost always different from the endoscopist's optimal "eye" setting) can be automatically obtained, even in the dark, and the ocular locked in this position. The camera lens is then also set at infinity, and the camera locked on to the eyepiece with the screw-clamp adapter (Fig. 2). The camera and Fiberscope may now be moved as a unit (Fig. 3), and the only focusing that remains to be attended to during the filming is the distal focus (Lens A onto Plane A). For this purpose, and also to keep the object of interest in view, a reflex camera is essential.

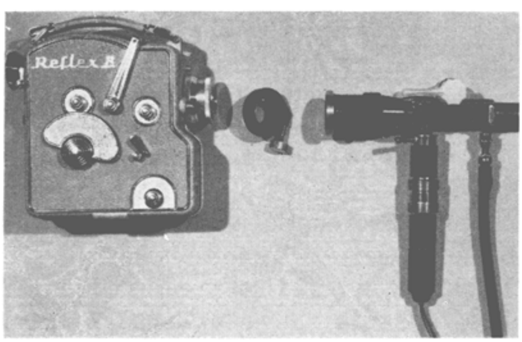

Fig. 2. Movie camera, coupling, and head of Fiberscope with electrical and air connections below, focusing handles at top, and hole (on other side of eyepiece) into which infinity lock fits.

Color Rendition

The nature of the optical glass used is such that there is maximal light transmission at wavelengths over 5200 A (i.e., green to red), with a fairly sharp decline below 5200 A. Fortunately, the mucosa is orange-red. The film used is designed for artificial light which is also deficient in the violet-blue range, and if correctly developed, the color rendition on the film is almost true. Color appearance can be somewhat improved by projection on to a greyish-white matte rather than a dead-white shiny surface. It should be remembered that when the light source is too close to a mucosal surface, there will be a red glow which may shift the balance of the color of the whole picture towards red.

Perception

Perception of moving pictures by a viewer depends on the inability to detect a gap which is of shorter duration than 0.1 sec. between pictures. Moving pictures depend on this fact to present a continuum of movement to the viewer. Photographs taken at 8 frames per second expose each frame for 1/19 sec. The use of moving pictures improves the resolution of the picture, especially when the object is moving slightly. The only "grain" visible will be that of the proximal end of the bundle.

Magnification

Magnification in the Fiberscope is a function of distance of the object from the objective window of the instrument so that the closer an object is, the larger it will appear. Size may thus only be estimated from experience and an appreciation of perspective. It should be remembered that the fiber bundle transmits the image exactly as it receives it and that the proximal plane image can only be enlarged a small amount (up to about 20 times) before such enlargement becomes self-defeating (as in enlarging a halftone, where eventually only meaningless dots are seen).

TECHNIQUE FOR MOVIE PHOTOGRAPHY

Equipment

A reflex movie camera with variable film speed is essential. We have found the Camex 8-mm. reflex movie camera (Fig. 2) satisfactory except for the clockwork drive which most times is exhausted before a sequence can be completed. An automatic coupled exposure meter is of no help and may be a disadvantage.

The 20-mm. Cinor B lens gives the best image size, occupying almost as much of each frame as can be used. The 12.5-mm. lens normally supplied with the camera produces too small an image. For *coupling*, an adapter which screws into the Cinor lens and clamps onto the eyepiece is all that is needed; this is supplied with each Fiberscope (Fig. 2).

We use Super Ektachrome ER Type B film (artificial light). Any good projector which can be slowed to 8 frames per second is adequate; the projector we use (a Paillard-Bolex "18/5" 8-mm.) can project at 5 frames per second without visible flicker, but with reduced illumination. For still photography a 35-mm. reflex camera with a 50- to 75-mm. f. 2.0 lens and an adapter, and film speed settings of 1/10, 1/20, or 1/25 sec. is good. The Exakta is satisfactory but heavy.

Procedure

Before photographing a lesion, we identify the sequence by taking pictures for 3 sec. of the patients name and the date and description of the lesion written on a sheet of white paper with a felt pen, and held against a fluorescent X-ray viewbox. The setting for this is f. 5.6 at 24 frames per second, and the distance, ± 4 ft. Next, the relevant X-ray picture is photographed for 10 sec. in the same way at 16–24 frames per second depending on the density of the film. The camera is then *rewound and reset at* f. 1.9, *infinity, and 8 frames per second,* and coupled to the eyepiece of the Fiberscope, which has been set to the infinity focus. At this point one should be able to see the end of the fiber bundle most clearly. The image will appear larger through the camera finder since it is magnified a further 1.6 times by the 20-mm. lens. The cross-hairs of the viewfinder should then be centered to be sure the camera is well seated on the eyepiece..

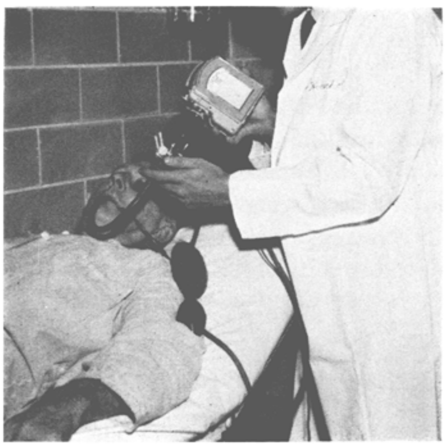

Fig. 3. Camera attached to fiberscope during examination. Note dental suction in mouth.

The transformer is set at 9 or 10 v, and pictures may then be taken with the object held in focus by the distal focusing mechanisms while viewing through the camera. If a moving area is to be photographed, a trial run, without photographing, should be tried to be sure of the range and direction of focusing needs.

Illumination

For normal endoscopy, a setting on the transformer of 6 or 7 v is adequate, while for photography the setting should be 9 or 10 v. At this high setting, prolonged contact with an area of mucosa could conceivably produce thermal injury, although we have not seen any concrete evidence of any significant burns. One should be particularly careful of the gradual deterioration of the bulb, particularly if much photography is done. While we have not completely burned out a bulb in 1000 examinations, the bulbs have shown aging by blackening, providing illumination inadequate for photography but still bright enough for visual endoscopy. With a new bulb, the setting at 9 or 10 v may even be too much, particularly if a white or shiny surface is being photographed. With experience, it becomes easy to judge the correct amount of light. The average commercial light meter is not sensitive enough to measure the light coming out of the ocular.

Sequence Length

An average sequence of a static lesion which can be seen in its entirety requires only 15–25 sec., while an area which is moving (antrum-pylorus, stoma-jejunum) may need 30–60 sec. Accurate focusing is especially important with the latter sequences.

Still Photography

An exposure of 1/10 to 1/20 sec. at f. 2.0 is usually correct for the majority of well-illuminated areas.

SUMMARY

The technic and principles of taking photographs through the Fiberscope are described. Since the fiber optic system transmits enough of the light normally used for endoscopy, no accessory illumination is required even for good color movies.

Four criteria for adequate endoscopic color photography have been met by the Fiberscope: (1) adequate light transmission, (2) adequate image resolution, (3) adequate color rendition, and (4) ease of making photographs with available light and no accessory equipment.

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REFERENCE

1. Hirschowitz, B. I. Endoscopic examination of the stomach and duodenal cap with the Fiberscope. *Lancet* 5 (20) :1074, 1961.