Experience with videotape monitoring of microscopic neurosurgical procedures

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This report describes technical details of a low-cost color videotape system for monitoring microneurosurgical procedures. The participation of audiovisual specialists was proven essential in insuring maximum effectiveness of these projects.

KEY WORDS • microneurosurgery • audiovisual aids • closed circuit television

With the establishment of a Neurological Institute Biomedical Communications Committee in 1970, a series of investigations in audiovisual applications and techniques was initiated. In 1971 the Columbia University Faculty of Medicine established an Audiovisual Service. With cooperation of the National Medical Audiovisual Center in Atlanta, an audiovisual advisory council was formed to direct integration and utilization of the increasing number of planned audiovisual units into the existing and future educational framework. One result of these investigations has been the development of a low-cost color video-recording system for use in microneurosurgery.

Materials and Method

Apparatus

The basic operating microscopes at the Neurological Institute have been the Zeiss OPMI 1 and OPMI 6,* the latter with motorized zoom magnification and focus. Both can be fitted with a Zeiss 50-50 beam splitter* to allow a stereo observation tube for the operating assistant and a monocular “C” mount cinemagraphic accessory tube.

While still and cine photography and high-resolution black-and-white television have been well established in many centers, color television recording through the microscope has posed special problems. The size of studio or earlier portable cameras precluded direct mounting onto the microscope. Early experiences with coherent fiber optic bundles were expensive and produced unsatisfactory resolution and only fair color rendition; a series of alterations and modifications by the optical companies failed to correct the faults. The Columbia Broadcasting System (CBS) field sequential system included a small, sensitive color camera giving excellent rendition. It was not compatible with the National

*Zeiss OPMI 1 and OPMI 6 and Zeiss 50-50 beam splitter manufactured by Carl Zeiss, Inc., 444 Fifth Avenue, New York, New York 10018.
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Television Systems Committee (NTSC) standard, however, making expensive and time-consuming conversion necessary for use with conventional monitors and videotape recorders (VTRs). At high magnification, light available to virtually all cameras tested was inadequate. Accordingly, a fiber optic booster light* was fitted and used during all recording.

Early in 1973, Magnavox developed a small self-contained color camera, the Magnavox Chromavue 400.† This instrument weighed less than 7 lb, and was equipped with "C" mountings strong enough to support the camera in any position. The camera had the advantages of single tube design and considerable automatic gain and chromo focusing circuitry; it sold for $2500, including the camera control unit (CCU). With the assistance of the video products division of the company, the camera was coupled to the standard Zeiss photographic arm (Fig. 1). The viewer and the handle had previously been removed, and with minimum adjustments an excellent color image was achieved.

The closed circuit television system (CCTV) currently in use at the Neurological Institute is shown in Fig. 2. The output from the camera is fed into the typewriter-sized camera control unit, located in the operating room. This amplified and mixed signal is led by coaxial cable‡ into a patch panel distribution rack in the TV control room; the rack's inputs are designed to accept both audio and visual feeds from multiple sources. Following optional image enhancing§ the signal is patched into a video distribution amplifier.**

*Fiber optic booster light manufactured by Wehmelite, C. 2005 Lakeside Drive, Lexington, Kentucky 40502.
†Magnavox Chromavue 400 manufactured by F&B/CECO Video Products Division, Magnavox, 315 West 43rd Street, New York, New York 10036.
‡Coaxial cable manufactured by Belden Corporation, 2000 South Batavia Avenue, Geneva, Illinois 60134.
§CBS Mark III image enhancer manufactured by CBS Labs, 227 High Ridge Road, Stamford, Connecticut 06905.
**Grass Valley 901 DP Video distribution amplifier manufactured by Grass Valley Group, Inc., P.O. Box 1114, Grass Valley, California 95945.

and fed directly into monitors* in the operating room, gallery and classrooms. Master recording is accomplished by simultaneously patching into 1-inch, reel-to-reel videotape recorders.† The master tape is then edited and transferred to three-quarter-inch U-matic cassettes. With the very acceptable quality of televised radiographs, provision has been made for two-way audio and visual communications between the neuro-radiology departments and the operating room. As networks have been extended, however, care has had to be taken to avoid terminating more than one video feed into the same monitor.

*Sony CVM 1720 monitors manufactured by Sony Corporation of America, 47-47 Van Dam Street, Long Island City, New York 11101.
†Ampex 7900-25 video tape recorders manufactured by Ampex Corporation, Video Products Division, 401 Broadway, Redwood City, California 94063.

Fig. 1. Magnavox Chromavue 400 video color camera coupled to Zeiss OPMI 6 microscope.
The basic functional unit for microsurgical monitoring is the Magnavox camera with its camera control unit; the image is fed directly by cable to one or more direct video color monitors. These monitors differ from conventional color sets by the addition of cable inputs that allow the direct video signal to be fed into the monitor; this avoidance of intermediate conversion into a radiofrequency (RF) stage produces superior picture quality.

For simple recording, one lead from the camera control unit is fed into a standard ¾ in. portable cassette recorder-player,* located close to the operating room. For replay the recorder-player is connected directly to a monitor.

**Operational Problems**

Several problems existed in the original camera unit. Line voltage changes such as those that occur with concurrent operation of elaborate x-ray equipment affected the imaging adversely. Also, the original automatic focus circuit, whose precise functioning is necessary for proper colorimetry, was heat sensitive; heat accumulation from the microscope's own tungsten lamp and the additional booster lighting, all under the sterile microscope cover, often became excessive. Changes in draping and circuit modifications by the company have resolved these problems.

A less technical consideration has involved retraining the surgeon in the use of the microscope with camera. Because the depth of focus of the operator is considerably greater than that of the camera, the following focusing procedure is used. With the microscope set at a high magnification and the oculars set to zero, the microscope is focused to produce the sharpest possible image on the operating room monitor. The surgeon's and assistant's eyepieces are then adjusted for individual sharpness. The surgeon must remember to adjust the microscope for the TV image when he changes planes of work, even though his own direct view of the

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*Sony V01800 cassette recorder-player manufactured by Sony Corporation of America, 47-47 Van Dam Street, Long Island City, New York 11101.
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operative field is adequate. Also, because the camera records only two-thirds of the microscopic field, he must keep the area of interest centered. These adjustments in technique, however, are minor and do not disrupt the normal use of the microscope.

An important advantage of this system is the ease with which it can be set up and run. Operating room nursing personnel experienced with the microscope quickly learn to attach the camera and couple the CCU and monitors. Furthermore, draping the camera requires minimal deviation from normal protocol.

**Discussion**

The increasing use of the microscope in surgery, and the application of audiovisual devices to education and training, have stimulated interest in the adaptation of video taping to the operating microscope. Despite large expenditures of money in preliminary undertakings across the country, little of this experience has reached the medical or bioengineering literature. Nor has the crucial role of the audiovisual specialist been emphasized in the development and the functioning of an effective closed circuit television (CCTV) system.

The benefits of an effective microsurgical CCTV system are many. Interested house staff, students and nursing personnel can conveniently watch and learn surgical techniques. The system can accommodate many spectators, each of whom can view the procedure continuously. Obviously the risks of operating room contamination are reduced when visitors can follow the surgery at a remote location. Residents and staff can retrieve and review recent cases. Unusual surgical lesions or techniques can be preserved and incorporated into subsequent lectures or grand rounds presentations. Techniques are available for transposing taped material to slides for journal or lecture illustrations. The availability of erasure and reuse of tapes reduces the cost per hour far below that of color film recording.

The relatively low cost of the basic components (Table 1) favors the early acquisition of ancillary audiovisual production equipment, such as editing or display units. In addition, the components are compatible with most of the tape and hardware resources in use institutionally and commercially. Thus, the initial microscopic monitoring unit can be expanded with, and integrated into, more complex audiovisual equipment and programs.

The productivity of our microneurosurgical CCTV unit since its development in May, 1973, is illustrated in Table 2. The reduction of equipment "down time" and the increasing experience of personnel involved, including physicians, has steadily increased the output efficiency. Even so, a major obstacle to the more rapid production of finished material remains the investment of time required to edit raw tape. Editing time is substantially reduced by designation, prior to shooting, of the segments to be recorded.

The vital contribution of audiovisual specialists in all phases cannot be overemphasized. In the early stages, the overview offered by the service's director, producer, and technical staff insured proper integration of individual projects and prompt utilization of material for teaching purposes.

From a purely technical standpoint, the service's expertise has saved considerable sums of money. With systematic and in-

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**TABLE 1**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Magnavox Chromavue 400 Camera</td>
<td>$2500</td>
</tr>
<tr>
<td>Wehmerlite fiber optic booster light</td>
<td>600</td>
</tr>
<tr>
<td>Zeiss 50-50 beam-splitter</td>
<td>450</td>
</tr>
<tr>
<td>Zeiss cine photoadapter</td>
<td>350</td>
</tr>
<tr>
<td>SONY CVM 1720 monitor receiver</td>
<td>850</td>
</tr>
<tr>
<td>SONY VO 1800 recorder-player</td>
<td>1475</td>
</tr>
<tr>
<td><strong>Total cost of basic components</strong></td>
<td><strong>$6225</strong></td>
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**TABLE 2**

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<thead>
<tr>
<th>Utilization (since May, 1973) of the microneurosurgical video units*</th>
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<tr>
<td>neuroscience jobs</td>
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<tr>
<td>neuroscience programs</td>
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<tr>
<td>microneurosurgical jobs</td>
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<tr>
<td>programs completed</td>
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<tr>
<td>seminars completed</td>
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<tr>
<td>programs in preparation</td>
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<tr>
<td>microneurosurgical monitoring (hrs)</td>
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</tbody>
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* Jobs are defined as discrete taping assignments; programs constitute edited, narrated or graphically modified productions; and seminars are segments of programs.
formed purchasing, redundant or incompatible equipment has been avoided and installation problems have been minimized.

Maintenance and modification of equipment deserve separate note. All but the simplest systems, designed for the most limited purposes, require surprisingly extensive maintenance, repair, and modifications; only rarely are these services satisfactorily performed by retailing companies. Not infrequently, our audiovisual engineers have been able to suggest design refinements substantial enough to be subsequently incorporated into future production models.

An equally important function of the audiovisual service is the processing of raw taped material into finished, effective programs and productions; most clinicians fail to appreciate the amount of time required to direct, produce, and edit tape. Finally, the incorporation of modern graphics and taping techniques is especially desirable for enhancing the education and training value of the material.

Acknowledgments
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References

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