Television in the Operating Suite and Special Areas

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MEDICAL TELEVISION has reached a degree of seniority: 1972 will mark a quarter of a century since its use began. This article is intended to describe the applications of television currently or potentially useful in operating suites and special areas and the engineering and technical provisions that these applications require.

Applications

Three basic factors determine the success of medical television: the viewers and their needs, the inherent capability of television to satisfy the needs, and the adequacy of the specific television system provided.

Viewers and Their Needs

The operating team itself can make effective use of television, as can those who need to observe their activities. The latter group has historical precedence: the original closed-circuit medical television presentation in 1947 at the Johns Hopkins Hospital was a demonstration of operating techniques.[1] The first medical use of color television was also for teaching and demonstration: a presentation of surgery at the annual session of the American Medical Association in 1949.[2]

Observers: Teaching and Demonstration

Most medical television presentations are viewed by practitioners, interns and residents, and medical students. Presentations for practitioners are the concern of the staff of the Regional Medical Program and of departments of continuing medical education. Those for residents and interns are the concern of the specialists under whom they work. Presentations for medical students are the concern of the medical schools. It is important that the needs of all these groups be served by one television system. Representatives of the Regional Medical Program and the department of continuing education, hospital staff members, and the medical school should be consulted during the planning process. Arriving at a common plan is possible because all groups will use the system in varying degrees to follow surgical procedures, patient reaction, and other activities and procedures within the operating room.

The presentation of surgical procedures developed early popularity. By 1960 several hospitals routinely televised all surgery. In a situation typical of that period, one camera was attached to the overhead surgical lamp so that it was focused upon the area at which the light was directed. A nurse or technician served as camera operator. Viewing monitors were located in the surgical waiting room, near the surgical nurses' station, and perhaps in the office of the chief of surgery. Typically, viewers would include the family doctor of the patient, visiting specialists, surgical residents, and other medical and nursing students. In addition, a television cable and two audio lines ran from the operating room to the hospital auditorium, and on occasion a large group would assemble in the auditorium for a demonstration of unusual importance.

Demonstration of surgical procedures is no longer all there is to medical television. Today, this accounts for less than a tenth of the television activity in the hospital or medical school.

Improved equipment has greatly increased versatility. For example, it is now easy to televise procedures which can be done only by operating microscope. Figure 1 shows a stapedectomy being televised with the House–Urban camera, which employs prisms to deliver a two-dimensional picture to a half-inch vidicon camera tube mounted on the microscope. A reinforced counterweight accommo-

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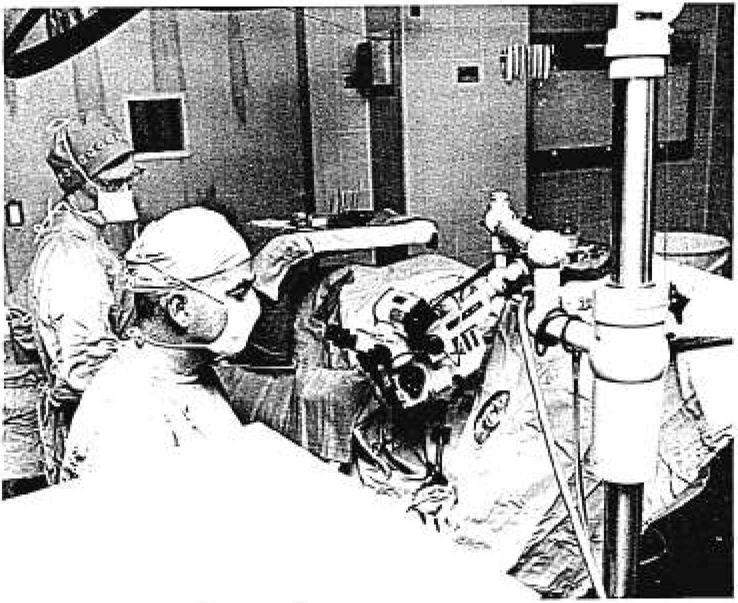

FIG. 1. House–Urban camera in position for stapedectomy procedure, with television monitor in the foreground. The microphone is attached to the operating microscope directly below the binocular eyepieces.

dates the camera and a microphone without interfering with the flexibility needed for operation of the microscope. A modification of this procedure was tried in Bordeaux, France, to provide a complete three-dimensional view of ear surgery for a convention of 55 ear, nose, and throat specialists. The audience used polaroid glasses to keep separate the images obtained from cameras attached to the adjacent oculars of the binocular microscope. The image was displayed on two monitors at a right angle to each other and received through a semireflecting glass positioned at a 45° angle to each of the monitors.[3] The University of Texas Dental Branch, Houston, is currently preparing an elaborate system of three-dimensional television to be used in training students working in multidisciplinary laboratories. Within a few years it may be possible to specify those applications which demonstrably benefit from such devices.

At the University of California, School of Pharmacy students approached their pharmacology instructor with the request to observe the effects of premedication and anesthetic agents. With 70 students in the class, there had been no way of getting them into the operating room. The solution was to send in television equipment with an anesthesiologist, who described the patient's condition and the drugs administered and answered questions from student viewers relayed from the classroom. The demonstration stimulated so much student interest that similar presentations on videotape are now presented regularly to medical as well as pharmacy students.

The television camera can be focussed upon the duties of a member of the operating team, such as the nurse or an anesthetist. The opportunity to observe the activity of the team member against the background of an actual operation lends interest and significance at a particular stage of the learning process. Much the same is true of televised demonstrations of special equipment, such as the heart–lung machine, which enable the viewer to grasp a principle or to gain a general understanding of procedures. When the viewer is being trained as a team member, appropriate use of television can provide more time for practice by shortening the duration of introductory instruction.

Color television has limited usefulness in teaching and demonstration. Chu and Schramm [4] have concluded that color in film or television often does not significantly improve learning *per se*, but that it may bring about more favorable attitudes toward (medical and other) instructional television. It may be essential, however, in the learning of discrimination tasks that can be identified only by color.[4] Based on our experience at the University of California San Francisco Medical Center, we estimate that color is essential in 30 per cent of the potential applications of television for teaching and demonstration. Probably those who insist on "color or nothing" and those who claim "monochrome does it all" are both incorrect.

Operating Team: Improved Performance

The operating team uses television to improve operating performance and to make possible operations that could not be done without television. Diagnostic and preparatory information can be obtained by television. For example, increasing use is now being made of televised endoscopy as part of the clinical examination. The most successful instruments at present still use a rigid hollow shaft, but progress in fiber optics may soon make possible a bundle of flexible fibers that will deliver light to the cavity and return a picture of relatively high definition. At one time it was felt that the operating team would benefit from the display of pathologic material on the monitor as the pathologist in his laboratory discussed his differential diagnosis with those in the operating room, but recent experience indicates that prompt delivery of the diagnosis, not the televised display of the material, is of chief importance.

Operating team performance can be reviewed in videotape recordings. In the past it has been difficult to identify the reasons for mistakes, missed assignments, or problems with the location of operating room equipment. Failure to resolve such issues frequently is attributed to defensiveness or stubbornness, when in fact each member of the team sees the problem only from his own frame of reference. A videotape recording made with a wide-angle lens to include all activities within the operating room is an objective record. Its review should not be conducted in the spirit of identifying the guilty party; it is most effective when used as an aid in helping every member to see more clearly what he can do to improve the team's performance.

Those who have much experience in doing televised demonstrations for others become adept at *indirect surgery*, performed with the eyes on the monitor rather than on the field. This technique is also used when no audience is involved, particularly in visualization of small pathological entities such as tiny aneurysms. A good television camera with a zoom lens which has an added +2 or +3 diopter photar lens is focused on the field, using a fiber optic light source. Manipulations are performed under the guidance of the magnified television image on the monitor. Depth of instrument penetration is determined by clarity of focus at the instrument tip.[5]

Indirect surgery is also involved in televised radiofluoroscopic control. Television has accounted for renewed interest in the use of trans-sphenoidal surgical excision of tumors of the pituitary fossa. The horizontal-beam image from a portable image intensifier is picked up by a television camera and displayed on a monitor just behind and above the patient so that the surgeon may observe it without disturbing his position. Radioscopic control is used only as required during the operative procedure, and only a few seconds of radiation exposure are necessary at each stage of the operation to insure accurate placement of instruments. Hardy *et al.* first reported this technique, which invalidates certain previous pertinent criticisms of this approach. Hardy was guided solely by the monitor in judging the depth of the instrument penetration and manipulations in the sella turcica.[6] Televised radioscopic control has also been used with indirect surgery in intraocular foreign-body extraction.[7]

Inherent Capabilities of Television

The experience of other hospitals and schools with television applications can be a useful guide for planners designing television systems. However, some needs call for new, untried applications. There is a good chance that these will be successful if they make use of the six inherent capabilities of television, which may be applied singly or in combination. They were first described in 1963,[8] and no others of equal generality have since been identified.

Image Multiplication

Image multiplication is the simultaneous display of the same information at two or more physically-separated locations. The placing of monitors in the doctors' lounge and dressing area, the nurses' station, and other locations is an example.

Image Magnification

Image magnification is the display of a television image with enlargement of plane dimensions to a minimum of 50 times those of the actual object. The use of television for indirect surgery of small aneurysms, as described above, is an example.

Image Association

Image association is the simultaneous display on a single viewing monitor of the signals from two or more live cameras. This may be accomplished by superimposition or by the split-screen effect obtained from a special-effects generator. This capability can be advantageous to viewers outside the operating room. For example, in cardiac operations the heart may be shown along with the electrocardiogram and pressure tracings as they appear on the anesthetist's oscilloscope.

Image Transportation

Image transportation is the movement of an image from or to an otherwise-inaccessible location. Operating suites and special areas often are inaccessible for reasons of physical safety. In areas of radiation hazard, the safety of the observer is of primary concern; within the operating room, the safety of the patient requires his isolation from direct contact with the observers. Only television is capable of instantaneously transporting both sound and picture from one location to another.

Image Transformation

Image transformation is the instantaneous display of attributes of an object which would not be visible without special alteration of the electronic components of the television-originating subsystem; it does not depend upon magnification. This unique capability of television is seldom used. The only current application relating to operating suites and special areas seems to be color translation and contrast enhancement of roentgenograms.[9] In the basic sciences some use is being made of vidicon tubes sensitive to ultraviolet light. Substances which appear transparent to white light are revealed clearly.[10] An example is the mounting of an ultraviolet-sensitive television camera over a microscope to study the nucleus of a sperm cell.

Image Memory

Image memory is the subsequent display of information originally obtained from a live television camera. If one wishes to store a sequence lasting longer than 20 seconds, the best current equipment is the videotape recorder. For a sequence that lasts 20 seconds or less, or for a collection of a thousand single frames, the best current equipment is the disc recorder. This device is capable of storing pictures on both sides of a 3/16 inch thick aluminum disc coated with nickel cobalt. One example of the utility of this device occurs in recording a fluoroscopic image. A patient can be televised as he drinks an opaque solution; the entire action can then be replayed immediately at the rate it occurred, or the sequence can be displayed one frame at a time for each 1/60th of a second.

Adequacy of the Specific System

The unfortunate consequences of planning an operating suite or special area without regard to the circulation pattern, the spatial arrangement, and the heating and electrical systems for the remainder of the hospital are generally recognized. Equally undesirable results can arise from failure to consider the total television system needed to serve the entire hospital and related teaching areas. If there is a qualified television coordinator on the staff, he should be consulted in the early stages of planning the operating suite. If not, it is important to seek outside assistance. The Council on Medical Television maintains a list of a few members who are known to have given such assistance. The persons listed are currently active in medical television in centers of medicine, nursing, pharmacy, and dentistry. Information may be obtained by writing to the Secretary.* As an alternative, in certain parts of the country it is possible to contract directly for the services of a full-time professional consultant.

To insure that the specific television system to be installed will be adequate for the applications intended, the planners and consultant must satisfy certain design requirements, prepare the design in terms of system components, and utilize realistic estimates of system use.

Design Requirements

Three requirements of system design are of particular importance to medical television: frequency of use, flexibility, and compatibility. The equipment needed for medical television must be of high quality, and it is expensive. The expense can be justified readily if there are sufficient worthwhile applications. A system that is rarely used because the equipment is inadequate to the applications required is wasteful, even if the initial cost is much less than that of adequate equipment.

Flexibility can contribute greatly to the efficiency of a television system. Some monitors should be mounted on mobile stands so that they can be wheeled to viewing locations that receive only occasional use. A high-quality camera that can be used in a studio, a laboratory, and an operating room justifies its cost more easily than a camera that is fixed in one location and used infrequently. A flexible distribution system may make it possible to keep a few videotape recorders operating at near optimum levels of use; an inflexible or incomplete distribution system may make it necessary to keep many recorders in locations that are rarely used.

A good solution to these system-design problems is arrived at by gaining the best possible idea of what the complete television system will be required to do. The skill of the designer lies in his ability to lay out the system so that it can grow in stages that conform to the expanding needs of the users. It is important to make sure that the simpler equipment, such as vidicon cameras, which should be selected for the early stage, can be operated in tandem with the image orthicon or plumbicon cameras scheduled for purchase at an intermediate stage and with the color equipment to be purchased at a still later stage. A monochrome camera is frequently used for showing x-rays in tandem with a color camera for showing the surgical field. Certain video (picture) cable is satisfactory for monochrome television but will not accommodate color signals satisfactorily. In this case, economy lies in the installation of a color-compatible distribution system at the outset.

System Components

There are three electronic components of even the simplest television system: the origination equipment, the distribution equipment, and the display equipment. It is reasonable to request a consultant to design his plans so that each component is expanded at each stage of system growth. One should not accept, for example, a plan that calls for procuring all origination equipment at stage 1, all distribution equipment at stage 2, and all display equipment at stage 3.

A persistent flaw in television system designs is the failure to plan for the human component, the technical staff needed to operate the system. In the long run it is more efficient to pay a competent television staff than to divert the productivity of a member of the

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operating team to this purpose. At each stage of system growth the number of persons needed to operate the equipment should be specified, along with a brief description of the duties of each. If television operators' salaries and other expenses cannot be paid out of the institution's operating budget, even though the equipment may be purchased from grant funds or donations, the feasibility of a television installation in the operating suite and special areas must be examined with extreme caution. It is highly desirable to designate or employ the television coordinator and to employ the chief engineer (or technician) as early in the planning phase as possible, so that they can contribute ideas to a system that they will operate.

Estimates of System Use

The efficiency of the television system design cannot exceed the quality of the estimates upon which it is based. A system designer must be furnished with the following estimates about television in the operating suite and special areas if he is to design a system for adequate service: (a) the television applications needed; (b) the location or locations from which the presentation is to originate; (c) the location or locations at which the presentation is to be viewed, including the number of persons to be accommodated at each location (the latter affects the number of viewing monitors needed); (d) a realistic estimate of the level of use, *i.e.*, those specific applications that will occur daily, weekly, or monthly, and those presentations that will occur simultaneously. It is admittedly impossible to make a perfect prediction, but it is better to have the consultant allow a margin for growth than to have him be misled by a committee that desires to protect itself by allowing a huge margin for error.

Technical Requirements

Physicians, administrators, and others responsible for hospital planning need not be expected to have exhaustive knowledge of every technical detail concerning the hospital television system. However, certain technical matters are almost certain to arise, and it is often useful to have some prior information regarding them.

In planning for the operating suite and special areas, the discussion of origination equipment is likely to concern the choice of camera, its associated mirror, boom, and lights, and electrical power requirements. Consideration of distribution equipment must involve a choice based upon picture quality and the distance between origination and display locations. Discussion of display equipment is almost certain to include the difference between receivers and monitors, their location in order to satisfy visual requirements, and a comparison of the monitor with projection television.

Origination Equipment: The Camera in the Operating Room

For operating-room demonstrations of anesthesiology, surgery, or nursing, experience has confirmed that at least two cameras are necessary. One is necessary to show the operating room procedures, a separate narrator, the charts and x-rays that are part of the case history, and anesthesia. The other camera, equipped with a remote-controlled mirror, shows the patient. Normally, this camera is located behind the operating team to obtain a view in perspective parallel to that seen by the team.

A 5- to 6-foot boom mounted on the camera supports a front surface mirror approximately 12 inches square. The mirror is remotely controlled by the cameraman to provide movement around a horizontal axis. This feature eliminates some movements of the camera, providing smooth changes that enhance viewing without distracting the operating team. Normally, the mirror is located most efficiently over the heads and at the center of the operating team huddle.

A spotlight, mounted on the camera, is positioned to provide the light for the surgical field via the mirror. This offers additional advantages when the spotlight is used in conjunction with an overhead surgical lamp that is placed at a slight angle. When used together they provide ideal lighting for the operator and increase picture depth for the viewers. If a team member obstructs the camera's

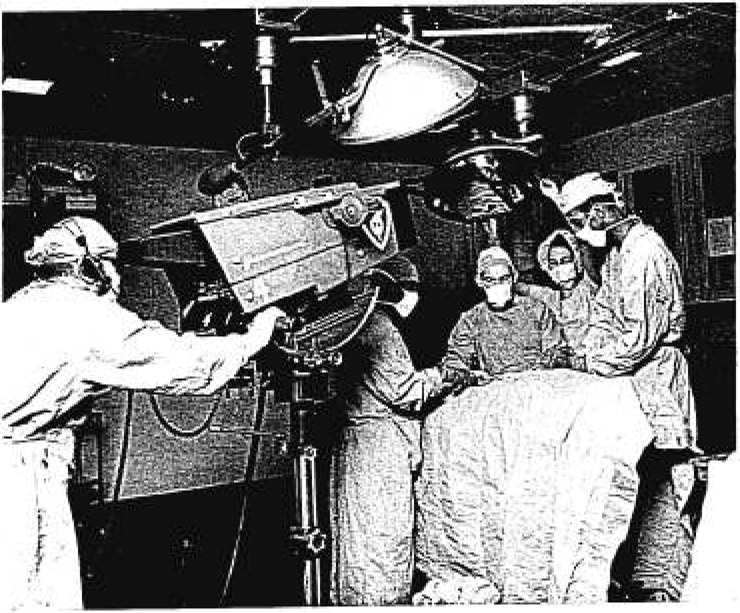

FIG. 2. Image orthicon camera with side-mounted spotlight and remote-controlled front surface mirror being utilized over operating field.

field of view with his head or his hand, the spotlight, reflecting by way of the mirror, produces a shadow that serves as a silent warning. Fixing the spotlight, boom, and mirror to the camera as shown in figure 2 insures that a constant amount of illumination is provided for the field of view at any camera position and any setting of the mirror.

It is advantageous to have the cameras mobile rather than permanently fixed over the operating room table, because fixed cameras are frequently unable to focus on a view that is not normally positioned. Moreover, it is too expensive to equip each operating room with its own high-quality television camera. The high-quality image orthicon camera minimizes picture flare caused by chrome instruments and saline solutions. Its additional weight makes it less sensitive to physical vibration, and there is practically no picture jiggle when a telephoto lens is used.

Television cameras in the operating room introduce electrical (ac) power problems that are not normally encountered at other originating locations. One serious problem is the complete loss of picture during the periods when electric cauterization is performed. Many types of filters have been explored to overcome this problem, but complete success has not been achieved. The best solution found to date is to install two 30-ampere circuits for the television ac supply from a separate source. This source must be isolated from the source supplying the other operating room circuits. The separate circuits must meet the Underwriters Safety Code requirements and that of the National Safety Code pertaining to equipment below the five-foot level. Isolation of sources is also required because high-quality television cameras require grounding that triggers the ground detector alarm systems.

Modern transistorized television camera equipment has greatly eased the ac current-load demands. In the majority of cases, normal wall outlets in institutional rooms are adequate to supply electrical power to television cameras. However, normal medical television presentations require additional outlets for lighting and electrical medical equipment in any area where television originations may be anticipated.

Distribution Equipment

There are two basic types of distribution systems to be considered, the video system and the radiofrequency (RF) system. When a system is designed to serve a single building or additional buildings nearby and the cable runs do not exceed 2,000 feet, the video system is recommended. It does not require additional electronic units, such as modulators and demodulators, that add considerable cost and maintenance problems. It is, therefore, more economical.

An RF system permits the transmission of a number of programs or channels on a single cable. This system is necessary if signals must be fed to other campus buildings that are some distance away.

A video system may be converted to an RF system at any time by adding the necessary electronic components, in the event that many more channels or greater transmission distances become necessary.

The major concern when planning a television distribution system in a new building is to incorporate conduit and cable passageways to all prospective areas where television may originate or be viewed. Plans for a 1½ inch conduit between the master control room, the "nerve center" of the distribution system, and each viewing or originating room must be incorporated. The minimum 1½ inch diameter conduit is required to accommodate a normal complement of two RG11 coaxial video cables and three two-wire shielded audio cables. The coaxial video cables in this conduit cannot tolerate any sharp turns; all turns or bends require a minimum 18-inch radius. Never mount the conduit adjacent to steam or hot water pipes; it should be separated from the pipes by a minimum distance of 12 inches.

The function of the first video cable of the normal complement is to transport the signal from the operating room to the master control room. The second video cable is necessary to carry a signal, which is frequently needed, in the opposite direction. Two of the three audio cables serve similar functions, and the third is necessary to accommodate two-way operational conversation by the television technicians on a headset intercom system without interruption of the television presentation itself. This complement of distribution cables provides added versatility. Two individual programs may be transported simultaneously to the same section of the hospital in either direction, or the duplicate cables can serve as a backup for one another in the event of a failure.

Distribution Cabinets

A television distribution cabinet is required in each room where programming is originated or viewed. The cabinet houses the patch panel that gives access to the distribution network. A workable cabinet is 12 inches by 12 inches by 6 inches in depth, flush-mounted in the wall with a lock door. The best location is one that means the least cable on the floor and the most convenience to the users. Unfortunately, this location is not always the most convenient for the electricians making the initial installation.

When rooms where television will be utilized are situated on the same floor and wing of the hospital, it is economical to install the lateral cables by a series loop through each room's distribution cabinet. All distribution cabinets in this area thus can be connected in series with a single conduit and be served with one complement of cables.

If the operating suite is designed with a patient-preparation room adjacent to each operating room, a dual-sided distribution cabinet should be built in the wall separating the two rooms. If the patient-holding room concept is adopted for the entire suite and each operating room does not have its individual patient-preparation room, the dual-sided distribution cabinet should be located in the wall separating the operating room from the inner hallway.

For aseptic conditions, and to minimize congestion in the operating room, it is desirable and practical to locate the camera-control console in the patient-preparation room or suite hallway when conducting a television presentation. In this mode only the television cameras are required in the operating room. Experience has shown that the patient-preparation room is most convenient when television is used because the control consoles do not interfere with hallway traffic.

A chrome door on each side of the wall for the distribution cabinet provides convenient access from the operating room as well as the patient-preparation room or hallway. Access to the distribution cabinet by this design also eliminates running cables through a doorway separating the two areas.

In either of the operating suite designs these cabinets should be conduited in series with a 1½ inch conduit to facilitate the series loop-through cabling. This cable complement would be the same type and quantity required between the master control room and the other lateral feeds.

A distribution cabinet accessible from either side of the wall should be considered for the postoperative recovery room. The recovery room should be tied in series with the operating suite distribution cabinets, and the same type of conduit and cabling should be used.

The balance of the medical television distribution system must be designed to meet the special and individual needs of each hospital. Multiple audio and video trunk lines may be conveniently installed vertically in the telephone service riser shafts to supply signals to lateral feeds on each floor. The lateral feeds in turn supply the signals to and from such areas as laboratories, classrooms, seminar rooms, auditoriums, and other clinical areas on each floor where potential originating or viewing areas are located.

Community Hospital Distribution

Distribution networks installed in community hospitals for in-service training are similar to those in teaching hospitals attached to medical schools. Customary originating and display locations are emergency areas, seminar rooms, nursing stations, and operating rooms. In-service training at community hospitals has been accelerated by the availability of videotapes and live network broadcasts made possible by some Regional Medical Programs.

Display Equipment

The viewing monitor is the basic display device for the medical television presentation in a closed-circuit system. Many systems use viewing monitors exclusively, with excellent results. However, a television projector may be considered for use in a large auditorium.

Projectors

A television image may be projected against a motion picture screen of auditorium size. Although a single projector seems more appropriate to an auditorium than hanging half-a-dozen or more monitors around the room, there are a number of disadvantages. The room must be almost completely darkened to obtain a good projected television image, because it is only ⅛ to ¹⁄₁₅ as bright as that of the viewing monitor. This means it is almost impossible to take notes during a presentation by projected television. If the auditorium floor has a steep slope under the seats and a shallow speakers' area it is difficult to obtain an undistorted image using a vertical screen. Viewers near the front of the auditorium tend to experience a certain loss of definition and gray scale in the image due to the high magnification. Chu and Schramm report that there is no evidence to suggest that projected (large-screen) television will improve learning from television in general.[4]

Viewing Monitors

Viewing monitors are capable of receiving the full video signal as it comes from the camera, permitting the maximum possible monochrome picture quality. They differ from the home television receiver in that they cannot receive a signal from a broadcast station without modification. The less-expensive home receiver is mass-produced in great quantity to satisfy less rigorous standards of home viewing. The monitor offers the extended definition and sharper gray scale that are important for clear display of, for example, pathology and x-rays.

The viewing monitors currently used most frequently in medical television have a 23-inch kinescope (picture) tube. The useful viewing area in front of each monitor is pie-shaped. It is important to make sure that no viewer is seated less than the minimum distance of six feet from the front of the monitor and that no viewer is seated beyond the maximum distance of 20 feet from the monitor. A line of vision not more than 45° from the center-line axis is the maximum angle recommended for viewing most material without objectionable distortion. No one within the viewing area should have to direct his gaze more than 30° above the horizontal to see the top of the kinescope tube.[11]

Recommendations

In preparing plans for the operating suite and special areas, the following television recommendations may prove useful:

1. Be sure to include television in the plans; after 25 years television is here to stay.

2. Be cautious about placing the major portion of the hospital television system within the operating suite; most systems are designed to serve a much broader range of applications.

3. Planning should begin with a consideration of how the various types of viewers and their needs can be served by the six inherent capabilities of television. Representatives of the medical school, the specialists, continuing education, and the Regional Medical Program should be consulted during the planning period.

4. Secure a competent person to design a hospital television system based upon the planning committee's final estimates of system use and the technical considerations outlined above.

5. Employ the top one or two members of the hospital television staff prior to the installation of the system so that he or they can accept responsibility for the system and verify the proof-of-performance measurements before the system is accepted.

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