Radiology in Sterile Areas

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THE PROVISION of radiologic facilities in sterile areas is related to the extent and complexity of radiologic facilities required and to the physical configuration of the areas. The operating theater, the neonatal ward, and especially the areas associated with organ transplantation commonly require both sterility and considerable x-ray facilities. The all-too-common use of a portable x-ray apparatus to provide these facilities has the disadvantage of introducing sepsis, and furthermore, even if a portable unit is permanently kept within the sterile area, it seldom has the capability needed to produce radiographic work of the highest quality.

Operating Theater

The radiographic needs in the operating theater depend on the types of the surgery undertaken. Thus, in a theater devoted to orthopedic surgery, facilities for radiography in two planes at right angles are a prerequisite, usually met with by the use of two portable x-ray units. Radiographs taken by these means are processed in a darkroom adjoining the theater and can be viewed through a viewing window without the surgeon's leaving the theater and without the x-ray films being reintroduced into the theater. This method is time-consuming; the development of a unit to circumvent this, with the x-ray tube and image intensifier mounted at either end of a half-circle arc, has provided a means whereby a fracture can be viewed in two planes immediately. Although most modern portable television fluoroscopic units are motorized, they are cumbersome and somewhat difficult to manipulate. They are, however, especially useful in the control of operative pinning of fractures. They are almost essential in the control of the introduction of an intramedullary pin.

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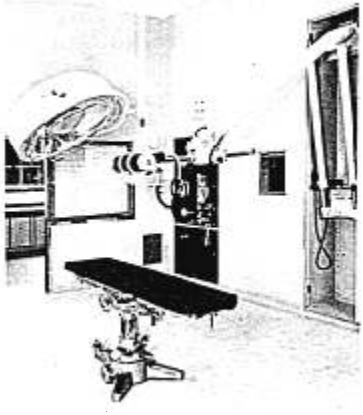

FIG. 1. Wall unit with the arm extended over the operating table (Watson & Sons, Ltd.).

Both these types of portable units have the disadvantage that an already-crowded operating theater is even more cluttered by their presence. In attempts to reduce the congestion on the operating-theater floor, various different x-ray installations have been proposed.

One of the earliest designs incorporated the x-ray tube within the operating-theater lamp (Siemens), but although it was sterile and easy to manipulate, the x-ray tube used was too low in output to achieve real success.

In modern operating-theater design, the x-ray tube is suspended from the ceiling (Sierex) or a hinged bracket from the wall (Watson), which enables the whole x-ray assembly to fold back into a recess in the wall. Because the generating equipment is located outside the operating theater and the exposure controlled by remote control, this method ensures complete sterility.

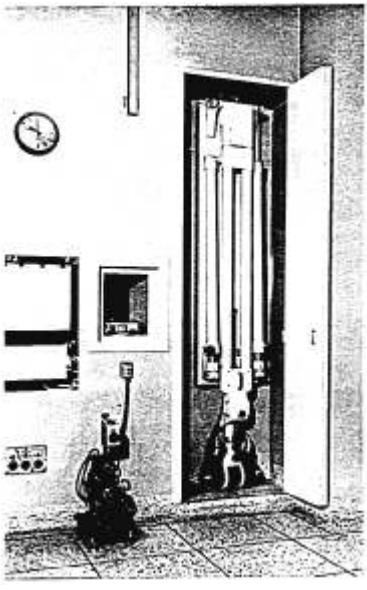

FIG. 2. Wall unit folded back in parking position in operating theater wall.

Figures 1, 2 and 3 illustrate the flexible wall unit development by Watson & Sons, Ltd., with the arm in its resting position and extended. This method is used in the neurological surgical theater at the Western General Hospital, Edinburgh. The advantage of the wall unit as opposed to the ceiling-mounted tube is that in operating theaters using the plenum system of ventilation the possibility of wound contamination is less.

For the ceiling-suspended x-ray tube (figs. 4, 5 and 6), Sierex, Ltd. have developed an ingenious nylon zip fastener which allows the tube to move from its parking recess into the operating theater, and to be positioned over the correct portion of the operating table. The opening of the recess doors and the inward, upward and downward movements of the tube column are completely motorized and remotely controlled. Linear motors bring the tube into the theater along its special ceiling track.

The generators and control centers for both these types of units lie outside the sterile area. Unlike mobile units, ceiling- and wall-mounted units can produce the power needed for rapid filming of rapid radiological sequences needed at operation. Facilities for immediate viewing are provided by the incorporation of a 10" Vidicon camera and television chain into the design. The Vidicon unit in this design is lo-

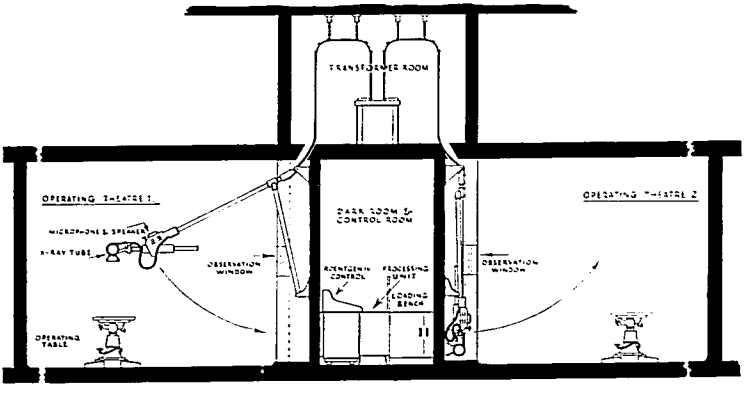

FIG. 3. Schematic illustration of twin theaters equipped with wall unit.

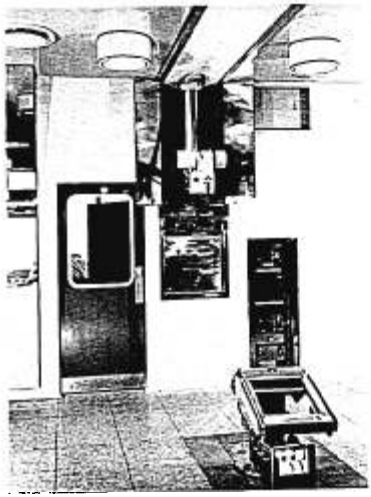

FIG. 4. Overhead tube in position in the operating theater. The nylon zip can be seen.

FIG. 5. Overhead tube in packed position with the doors closed.

cated beneath the operating table and the overhead x-ray tube automatically locates over it. The operating table top is radiolucent and has a "floating top," which enables the patient to be moved into any position where radiographs are needed. Such operating tables are commercially available (*e.g.*, Kifa). A design such as has been described and illustrated (fig. 4) is in operation in the cardiac operating theater of the Westminster Hospital, London.

It is probable that, in the future, smaller roller-film devices, possibly allowing suspension on the operating table with possibly the Vidicon camera enclosed in the table pedestal, will improve the design of recording the x-ray image.

The installation of this type of x-ray equipment is extremely costly, and the unit described has the disadvantage that its design is

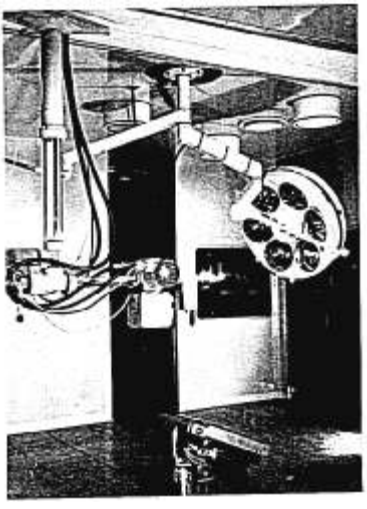

FIG. 6. Tube in position in the operating theater. The pedestal to which the radiolucent top attaches can be seen in the center.

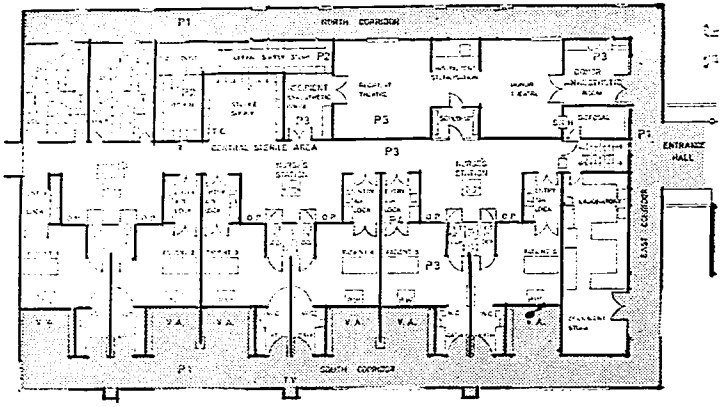

FIG. 7. Plan of Nuffield Institute showing the nonsterile area, corresponding to the area in which the mobile x-ray moves, shaded. The sites of the x-ray windows are indicated by the letters PW.

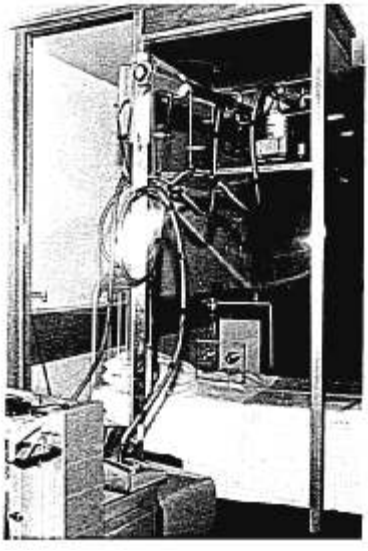

FIG. 8. Perspex bubble with x-ray tube in position for use.

largely specialized and does not have the versatility of some of the smaller mobile units.

Other manufacturers have combined the principle of the wall bracket with the unit holding both the Vidicon and the x-ray tube. The C.G.R. manufacturers have installed such a unit in the wall between two operating theaters so that both can be served. This allows visualization of any part of the anatomy to be made in planes at right angles. It does not, however, have facilities for rapid filming. This type of unit has its greatest use in orthopedic operating theaters.

Both these types of operating-theater units are so large and cost so much that they can be installed in only a few, or even in only one operating theater in a complex. It naturally follows that the program for use of a room with this specialized equipment must be preplanned carefully.

Neonatal Unit

In the neonatal unit, the number and demands for x-ray facilities are more limited. A portable unit permanently located within the sterile unit can "cover" several cribs. The needs for fluoroscopy with an intensifier and

television chain have not yet been fully developed.

Organ Transplantation Unit

X-ray facilities are also needed in the sterile areas associated with organ transplantation. In the immediate postoperative period, when immunosuppressive drugs have been administered, the patient's resistance to infection is minimal, and the need for asepsis is absolute. Pulmonary and abdominal complications are unfortunately not infrequent, and radiography is frequently needed. A mobile radiographic unit in each room is prohibitively expensive and unnecessary, while introduction of a mobile unit from outside the area introduces the hazard of infection.

The building of the Nuffield Transplantation Unit in Edinburgh allowed an opportunity to develop appropriate radiographic facilities. A central core of operating theater and six separate ward rooms constitute the sterile area (fig. 7). A constant filtered-air change is effected from this central area outwards into the nonsterile area. Around the sterile area the nonsterile corridor allows visitors and medical staff to inspect and converse by telephone with patients.

It was decided that radiographic services needed, usually chest or abdominal radiography, could best be provided by a mobile unit situated outside the sterile area in the nonsterile corridor but capable of radiography of the patient within his room. This prevents transfer of infection (in the event of a breakdown in asepsis) by movement of the apparatus from one room to another.

Figure 7 shows the ground plan of the Nuffield Transplantation Unit. The nonsterile corridor is shaded. The inspection window in each room was modified by installation of a specially-designed perspex panel (fig. 8). The panel, which extends from floor to ceiling, is 8 feet, 6 inches high and 3 feet, 6 inches wide. From it a bubble of perspex into which the x-ray tube can be placed projects into the room. The patient's bed can be wheeled into position beneath the tube and centering can be achieved by the light-beam diaphragm in the normal manner. The collimator is so arranged that remote control of the diaphragm is possible. The under-surface of the perspex projection, 0.5 cm thick, does not cause undue filtration of the x-ray beam. An insert of similar thickness in the panel below the perspex bubble allows use of a horizontal beam to take chest radiographs with the patient in a sitting position.

The cassettes are positioned by the nurse in the sterile area under directions of the radiographic technician, which are communicated through a two-way communications system. The cassettes are enclosed in a sterilized polythene bag and sealed with a heat knife. They are introduced into the sterile area via the usual route and after exposure are passed out of the sterile area through the same chute which disposes of soiled linen, etc. The patient's bed is wheeled back to its normal position after the radiographic procedure is completed. The same perspex windows have portals to which tubes can be connected so that the dialysing machine for renal failure can be kept outside the patient's room.

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