Appropriate Technology

Appropriate technology for diagnostic imaging in small hospitals

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How do you choose equipment for imaging from the bewildering and tempting array of alternatives, particularly when your budget is limited? The rules for shopping for images are the same as those for shopping in a supermarket: have a clear idea of what you need, and remember that cheapness may be a false economy.

Imaging for the non-radiologist in a small hospital means diagnostic *x* ray equipment or ultrasound or both. Ultrasound is extremely useful for looking at structures within the abdomen, for obstetrics, and for visualising the liver and abdominal and pelvic masses. It may also provide information about the kidney, pancreas, and gall bladder. There are no radiation hazards (so far as is known) and imaging is easy, although recording the image is more difficult and expensive. The main disadvantage is that ultrasound is time consuming for the physician as the work cannot be delegated.

X ray equipment has much wider application: in all cases of trauma, in many infections, especially those in the chest, in intestinal obstruction, in the investigation of genitourinary and gall bladder disease, and in obstetric practice. Apart from its wider usefulness, the work may be delegated to paramedical staff and there is a permanent record. The disadvantages are costs (US$25 000 upwards compared with $10 000 upwards for ultrasound) and the hazard of radiation, which may be controlled easily with proper precautions.

If you have the alternative, buy *x* ray equipment only. The use for ultrasound in a small hospital is so limited that money should be saved to purchase an *x* ray set.

X ray equipment

Any *x* ray installation requires an *x* ray set (generator, control, tube, and support for the patient); a darkroom with processing tanks, chemicals, cassettes, and films; and essential extras such as lead aprons, lead gloves, *x* ray viewing boxes, and film envelopes.

Provided properly designed equipment, such as the World Health Organisation Basic Radiological System (fig 1) is chosen, there is no need to have elaborate rooms with thick walls and lead doors. Local materials may be used; a firm and fairly flat floor is essential, and the ceiling height must be not less than 2·5 m. The room must be weatherproof, well ventilated, and at least 18 m². There must be easy access for beds and trolleys. The darkroom must be nearby, about 5 m², preferably with running water. A small storeroom or office of about 8 m² is helpful.

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The World Health Organisation recommends a fixed generator (as opposed to a mobile, "portable," or "ward" unit) with not less than 11 kW output. Specify this power, not less, because this is the minimum that will provide good quality chest *x* ray films as well as good radiographs of adult lumbar spines, the abdomen, and the fetus.

A mobile unit is unsatisfactory because it increases the radiation risks to staff and patients, operator training is more difficult, and the results are more variable. The only disadvantage of a fixed unit is for patients who are immobilised: they must be brought to the *x* ray department in their beds.

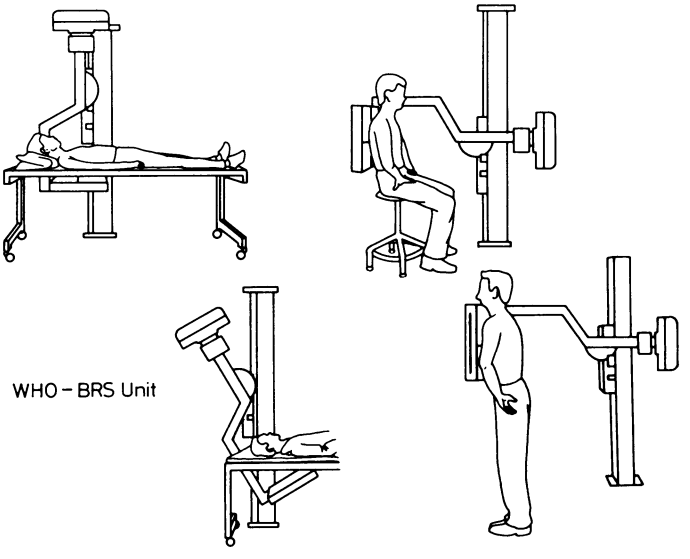

FIG 1—The design of the WHO Basic Radiological System permits 100 standard projections with simplicity yet accuracy. 11 kW is the minimum power requirement.

WHAT ELECTRICAL POWER IS REQUIRED?

If there is a small local electrical generator, an unreliable power supply, or a long cable from the nearest transformer choose a battery operated unit, but still of 11 kW. These may be recharged continuously from any 5 amp wall outlet (110 V or 220 V), and they go on working throughout the day even if the hospital generator operates only at night or if the main electrical supply is turned off at any time. Condenser discharge units are not satisfactory. They can produce satisfactory chest *x* ray films, but the spine or abdomen and pregnant women may have an *x* ray examination only at the expense of increased radiation and decreased quality. They need a constant electrical supply. They are an unacceptable alternative to an 11 kW fixed unit.

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WHO CAN OPERATE AN X RAY UNIT?

If the World Health Organisation Basic Radiological System is chosen anyone with a primary school education and preferably some previous hospital experience—for example, an orderly, nurse aid, assistant nurse, or lab technician—may learn to use it in a few weeks. WHO produces a simple step by step manual that covers all the necessary *x* ray examinations for a busy hospital (fig 2). Special techniques are shown for children. There is a section on patient care and radiation protection for staff and patients. The operator should first be taught at a large hospital by trained radiographers; this usually takes from two weeks to three months depending on the individual. With the basic radiological system such an operator may examine from three to 20 patients per day—with the help of a darkroom technician even more.

THE DARKROOM

A small truly "dark" room with running water and electric light is essential. A design for the film processing tank is shown in fig 3. The outside tank is best made out of high quality stainless steel that resists chemicals (ordinary stainless steel will survive about three months). Alternatively, the tank may be made of cement and preferably tiled. It is helpful to have hot water available if the ambient temperature drops below 20°C. Provided the appropriate chemicals are used, there is no need to have any method of cooling the processing tanks. The inner tanks, for developer and fixer, usually have about a 25 l capacity and should be of the appropriate quality of stainless steel. Plastic insert tanks are available, but they warp and have a relatively short life. Smaller self contained processing units are available with a 15 l capacity for developer and fixer, but these are suitable only for three to five patients per day.

X RAY FILMS AND CASSETTES

There are many different makes of *x* ray film, all of different speeds and quality. Usually the faster the film the poorer the quality of image. *X* ray films go between fluorescent screens inside cassettes, which must be lightproof and made of plastic or steel. Buy the best you can afford. Good cassettes will last 10 years in a small hospital and screens about five years. The fluorescent screens also come in many varieties of speed and quality. With an 11 kW generator choose a medium or standard speed rather than an ultra fast one. WHO recommends two sizes at least, 35 × 43 cm and 24 × 30 cm. Not more than two additional film sizes may be chosen, but make sure that these cassette sizes match the collimator (the beam limiting system)

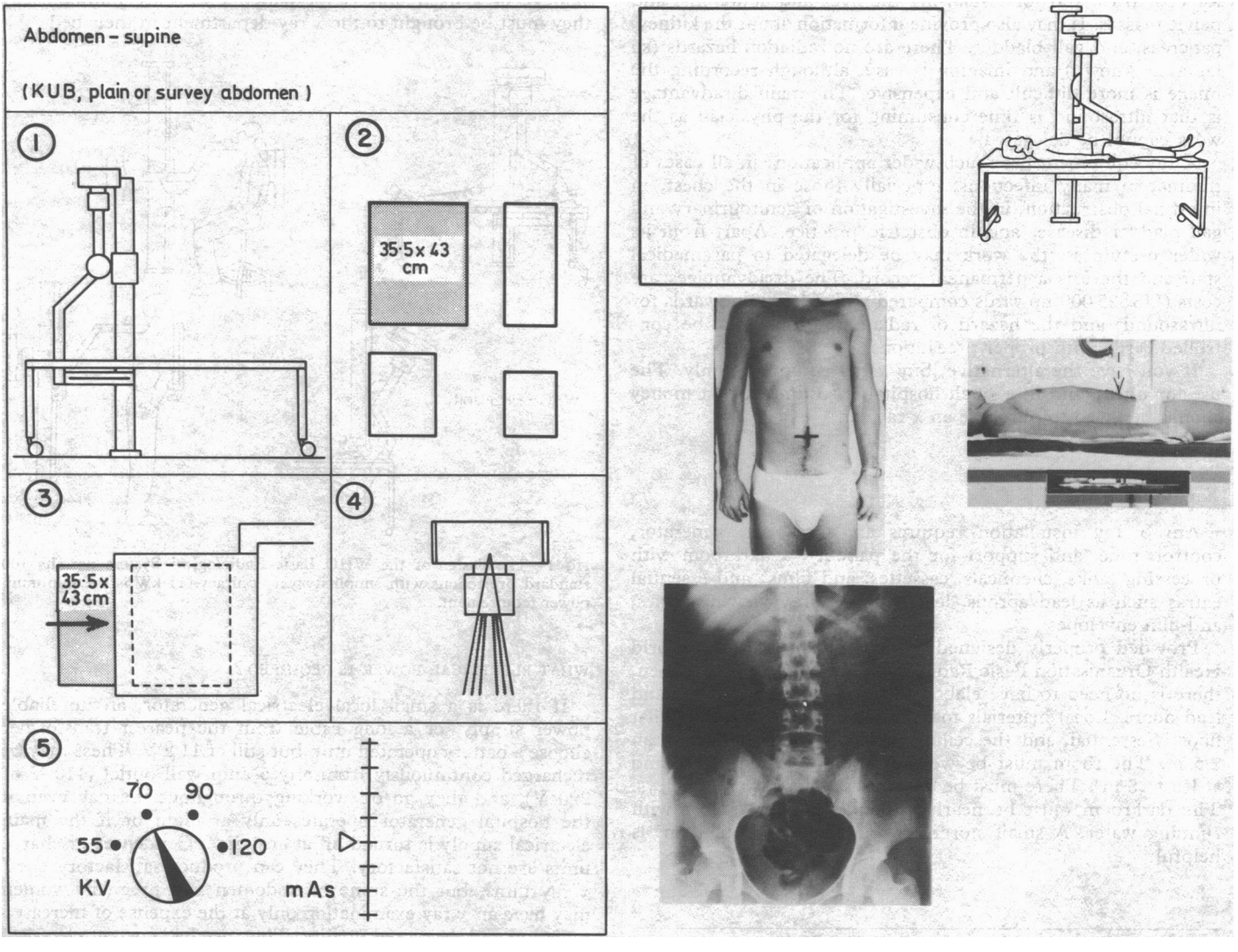

FIG 2—Left and right pages from the WHO *Manual of Radiographic Technique*. Space is available at the top of each page to write in additional instructions or reminders in the local language.

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of the *x* ray unit. One of the major disadvantages of a mobile unit is an inaccurate beam; this decreases quality and increases radiation hazards.

INSTALLATION AND COSTS

The manufacturer will install the machine, then an experienced radiographer must come to set the exposure charts or controls, using the film, screens, and processing chemicals

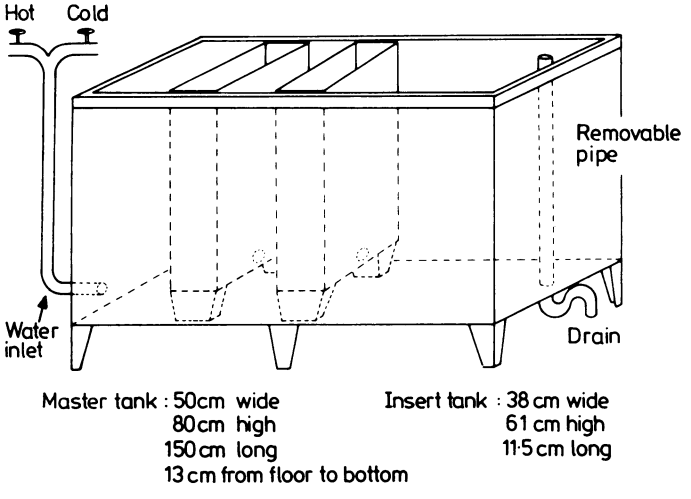

FIG 3—The WHO Basic Radiological System pattern for a simple *x* ray processing tank. As the number of patients increase additional chemical tanks can be added to this unit.

in your hospital. These cannot be preset in the factory. The exposures will then remain satisfactory until the type of film or screen is changed, when the exposure charts or controls must be recalibrated. At current costs, a satisfactory complete *x* ray installation complying with WHO's specifications, and providing the darkroom equipment and all the accessories, costs about $25 000. (Obviously these prices vary with different manufacturers and countries.) Do not, however, choose only by price: look carefully at the back up that is available. Is the manufacturer selling you equipment or does it come from "agents"? In general, beware of agents; experience suggests that the ability to sell *x* ray machines does not necessarily include a scholarly knowledge of *x* ray equipment. Similarly, choose *x* ray films that are similar to those in the larger hospitals in your country rather than an apparently cheaper supply from the local store.

Ultrasound

As with *x* ray sets, ultrasound comes in small, large, simple complex, cheap ($10 000), and expensive ($80 000 or more) varieties.

An entirely satisfactory ultrasound imaging unit, the size of a small suitcase and just as portable, is available for about $10 000; this will produce a black and white image on a small screen and needs a 5 amp AC source at 110 V or 220 V. It has one control knob. A week or two spent in a busy ultrasound department will allow an inexperienced doctor to recognise most of the important obstetric problems; any large tumour, cyst, or abscess in the liver or spleen or kidney; a swollen pancreas, a pancreatic pseudocyst; an ovarian, dermoid, or other pelvic tumour; and a sizable pelvic or peritoneal abscess or mass. With practice, the gall bladder, calculi, and obstructed bile ducts may be recognised and aortic aneurysms defined. Any diagnostic skills beyond these require much more training. It is important to remember that a physician will have to carry out each and every patient examination, and there is no place for the part time or occasional ultrasound technician.

LIMITATIONS AND COSTS

Recording the image from a small screen is a problem. A camera using a self developing (Polaroid or similar) film is available. These work well, but the film is not cheap and the camera is expensive. Even more expensive cameras use standard *x* ray film. Measuring the image on the screen directly with callipers is a compromise that is not accurate and not reproducible.

The design and production of ultrasound equipment are changing rapidly; any description now will be out of date before this article is printed. The description above provides a basis from which your requirements may be specified. Choose the supplier and manufacturer with the same care as you would an *x* ray set. If you have limited money, use a great deal of caution—a non-functioning $10 000 ultrasound unit is a frustrating item, and it is not even decorative.

Although I hope that this article reflects the views of the whole WHO expert group (Radiology in the Developing Countries), all of whom have many years of practical experience with the difficulties of imaging in small hospitals, nevertheless I must take personal responsibility for the opinions expressed. Dr N Racoveanu, chief of radiation medicine, World Health Organisation, Geneva, and his office will respond to requests for advice or refer the inquiry to one of the WHO advisers.

Recommended reading

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Clinical curio: beer and botulism

During an epidemic of type B botulism more women than men were affected. The implicated food was a nacho, a type of Mexican pizza, prepared with contaminated jalapeno peppers. A nacho is generally shared. The food histories of 12 groups of people who had shared contaminated nachos were analysed. Altogether 27 people had eaten the nachos. They were compared for age, sex, food eaten, and drink consumed. Seventeen of the 27 had developed botulism. Of 13 people who had drunk beer with their nacho, six became ill whereas, of 14 who had not drunk beer with their food, 11 became ill. Thus beer drinking may have a protective effect, though statistical analysis in this small group of subjects gives a probability of only 80%.

Beer contains over 800 compounds; in the complex interaction of malted barley, corn grits, and hops a toxin binding or destroying substance may possibly be formed.—R H SHIAPPACASSE, head of division of infectious diseases, Michigan.

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