Diagnostic Radiology in the Tropics: Technical Considerations

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ABSTRACT

An estimated two thirds of the world’s population is currently without access to diagnostic radiology services, and most of them live in resource-limited tropical regions with harsh environments. Most patients are diagnosed and treated in poorly equipped government-funded hospitals and clinics that have insufficiently trained staff and are barely operational. Any available imaging equipment is likely to be functioning suboptimally and be poorly maintained. The root of the problem is usually a lack of know-how and a quality culture, combined with insufficient basic equipment and infrastructure. Radiological imaging is an essential aspect of primary care and used in the critical diagnosis and management of trauma, tuberculosis, pneumonia, acquired immunodeficiency syndrome, cancer, and other respiratory and abdominal diseases. Considerations such as quality management and infrastructure, personnel, equipment, and radiation protection and safety are important to ensure the proper functioning and rational use of a diagnostic radiology facility in the tropics.

KEYWORDS: Diagnostic radiology equipment, imaging facility, quality management, radiation protection, radiology infrastructure, radiology safety, tropical imaging

If we look at a map of the world, we can see that the tropics covers much of Africa, South Asia, Southeast Asia, most of the islands of the Pacific, northern Australia, a large part of South America, Central America, and the Caribbean area. Within this region, we find deserts, tropical forests, large cities, small towns, small remote communities, heat, dust, cyclones, rain, and drought. Some inhabitants are extremely poor; others are among the world’s richest people. Civil war continues in some tropical countries and refugees flee for safety, causing great stress on the countries to which they escape, thus straining the health-care system of the host countries. In all this diversity, we see some common themes beginning to emerge. One must surely be the extremes of climate that mean harsh physical environments for radiology equipment, and another must be the extremes in socioeconomic status. The latter, particularly at its lowest end, puts enormous pressures on practice economic viability and staff qualification and training, along with its implications for effective radiological diagnosis. Radiological imaging is an essential aspect of primary care and used in the critical diagnosis and management of trauma, tuberculosis, pneumonia, acquired immunodeficiency syndrome, cancer, and other respiratory and abdominal diseases.

In countries where resources are limited, only a few wealthy individuals have access to well-equipped properly staffed private health-care institutions. Most of

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the population is treated in poorly equipped government-funded hospitals and clinics that have insufficient staff and are barely operational. Any imaging equipment that is available is likely to be functioning suboptimally and used incorrectly. Lengthy breakdowns due to the lack of proper maintenance and spare parts are common. Away from the larger cities, virtually no access to diagnostic imaging services is available.

The root of the problem is usually a lack of know-how, a quality culture, and insufficient basic equipment and economic infrastructure. Even well-educated and properly trained technologists/radiographers find it a challenge to improve the quality of radiological services if they do not have the proper facilities. As an example, in some extreme situations, darkrooms are often insufficiently protected from intruding daylight. They are inadequately ventilated, do not have clean water for film processing, and lack film supplies and sufficient knowledge of film technology. It can also be very difficult to keep processing chemicals cool enough for long-term storage. The effect on image quality is such that only the most obvious diagnostic conclusions can be reached.

QUALITY MANAGEMENT, INFRASTRUCTURE, AND CULTURE

In principle, diagnostic radiology practiced in the tropics could be expected to have a similar system in quality management as that seen in radiology practiced in other parts of the world. However, in isolated and resource-limited environments, there may well be a lack of knowledge of the importance of documented standards in the attainment and sustainability of good radiological practice. Basic measures, such as deciding on a mission statement and then ensuring that the financial structure of the facility is able to meet the outlined expectations, are especially important in a resource-intensive specialty such as diagnostic radiology. Efficiency of radiological practice is a major issue in the tropics. Despite the huge need for diagnosis, the use of manual (hand) processing reduces the use of basic X-ray equipment because a system is only as productive as its weakest link. It is tempting to think that to remove the film processing chain will increase efficiency. Indeed there are many examples where this is the case; however, there are also other examples of digital equipment being refused for several reasons. These include a rejection of soft copy reporting and archiving because there is “nothing to show for the examination,” equipment breakdown, and even the theft of computer equipment and power supply and environmental problems.

Personnel

A fully equipped diagnostic radiology facility typically has a multidisciplinary team consisting of radiologists, radiographers, technical assistants, ultrasonographers, nurses, medical physicists, service engineers, information technology specialists, and administrative staff. The facility staffing levels and the professional competence of the staff should be sufficient to provide safe and high-quality imaging examinations. However, in a smaller facility with limited resources, a full team may not always be available, and thus some members may have to perform the duties of others. Generally the technologists/radiographers are the workhorses in such facilities.

It should be the objective of a diagnostic radiology facility to ensure that at least the minimum required qualifications and continuing education for all staff involved in the delivery, supervision, support, and management of imaging services are consistent with clinical requirements and meet the appropriate national and local regulatory requirements or, in their absence, suitable international standards. All staff should receive adequate training according to their respective roles, and when the facility introduces any new techniques or imaging modality, proper training for users should be organized as a first step toward safe usage and competency.

Recognizing the severe shortage of qualified staff in most health facilities in the tropics, education and training should be given top priority. Training for professional staff is available remotely from several sources and notably from an excellent set of World Health Organization (WHO) publications that includes instructions for clinicians, radiographers, and technical staff.

Facility Organization and Management

Appropriate organizational structures and management systems should be in place to maximize the quality of service delivery and make efficient use of all resources. The commitment of senior management to good practice and quality improvement should be cultivated and documented in the quality manual. This can take the form of unified bidding for equipment for a region. The institution and facility should have an organizational chart that clearly shows the lines of authority. The sharing of responsibilities among different professionals should be clearly and unambiguously defined through job descriptions.

Premises

The premises of the radiological facility should be adequate to meet the specified objectives and operations of the institution safely. Care should be taken in the design phase to ensure that the premises allow a physical flow for staff and optimal patient access, comfort, and privacy. The use of an experienced professional architect is highly recommended. Thought must be given during
the planning stage to considering the other services necessary for good patient care, as well as effective patient movement and access. The special needs of the elderly and physically disadvantaged should also be taken into consideration as well as the large numbers of patients and their families coming from remote villages who may need to be accommodated with adequate waiting areas.

Appropriate space should be provided for imaging examination rooms, control rooms, film/image processing rooms, image interpretation rooms, recovery/post-procedural areas, waiting areas, patient movement within the facility, administration, film storage/library, record filing, engineering services, and staff accommodation. The building should offer protection from the environment, including being sealed from dust and rain. Humidity control using dehumidifiers is essential for much electrical equipment, particularly those that are computer controlled, and scientific measurement devices.

Air-conditioning, at least for part of the department areas, is highly desirable, especially for more advanced procedures and equipment. Attention must be paid to film storage/library facilities because they are generally not air-conditioned, and with the passage of time, fungus starts to grow on the films. Air-conditioning in a tropical health-care facility is very important to ensure that imaging systems function well within the recommended range of temperature and humidity, and thus should be well maintained.

Infection Control
Because radiological imaging is used in the tropics in the critical diagnosis and management of infectious diseases such as tuberculosis, pneumonia, acquired immunodeficiency syndrome, and other respiratory diseases, universal precautions should be strictly enforced. Staff members are exposed to various forms of pathogens and are at higher risk, thus requiring periodic medical surveillance. In cases where highly infectious diseases are suspected, cassettes should be wrapped in disposable plastic sheets to prevent possible nosocomial cross-infection.

EQUIPMENT

Equipment Policy
The facility should establish policies and procedures for documenting and monitoring equipment, such as purchase, use and replacement; an inventory; appropriate checks before use; quality control; maintenance, particularly with respect to safety and infection control; and data security and backup. One area of the department and hospital design that should be carefully considered is the electrical power supply. The services of a qualified electrical engineer can have far-reaching effects, especially in environments with an intermittent and unregulated voltage power supply. In these all too common cases, the use of uninterruptible power supplies should be used for all sensitive computer networks and computer-controlled equipment.

Only authorized trained staff should use equipment. The types of equipment to be documented include imaging equipment and modalities; software and hardware for digital imaging and teleradiology; associated imaging equipment such as viewing boxes; quality control phantoms, survey meters, and dosimeters; medical support equipment such as wheelchairs and trolleys; resuscitation equipment; anesthesia and sedation, and physiological monitoring; and administrative equipment such as computers, printers, and software. Appropriate equipment selection must be given priority to ensure that the equipment matches the mission of the facility, and it should be backed by a financial plan that includes the sustainable use of the equipment and budgeting for spare parts and maintenance throughout the life cycle of the equipment.

Equipment Purchase
Radiology is an equipment-intensive enterprise, and therefore an understanding of equipment life cycle (Fig. 1) and its associated costs is very important. In many cases, managers in remote locations are not well trained in these aspects and purchase equipment without understanding the long-term implications. For example, the purchase of equipment relying on expensive consumables, such as films, needs to be carefully considered. In some cases, this is dealt with by requiring patients to bring their own film; however, this scenario creates impossible quality control problems for all but the most basic forms of radiology. In the digital world, it is often mistakenly thought that once capital costs are covered, there will be no more expenses following the purchase. However, the cost of upgrades, both software and hardware, cannot be avoided for long periods, and redundancy and parts failure also ensure that those who do not have a secure financial plan will not be able to continue effective operation. Many hospitals in the tropics also depend on secondhand and gift equipment. This can be very successful; however, givers should also ensure that they abide by the WHO guidelines for equipment donations to ensure benefits for the recipient.
testing report; maintenance contract, and maintenance and safety testing records; quality control, calibration, and corrective action records; service records; and manufacturer’s specifications and any modifications.

RADIATION PROTECTION AND SAFETY
The requirements for radiation protection and safety are found in the International Basic Safety Standard. Furthermore, there is a requirement for other types of safety including electrical and mechanical safety.

Medical Exposure
Justification of each radiological examination must be initiated by the referring medical practitioner, but the final responsibility lies with the radiologist. Optimization of procedures is the joint responsibility of radiologists, radiographers, and medical physicists. Although this is important in all modalities, it becomes increasingly crucial for the modalities of mammography, computed tomography, and interventional radiology; for women who might be pregnant; and for children undergoing radiographic examinations. In addition, policies and procedures for risk assessment and management should be established. The following activities are recommended: dose audits for common examinations for comparison with dose reference levels; optimization of imaging examinations, especially for pediatric patients, pregnant patients, or potentially pregnant patients; documentation of fetal dose estimates; and accidents and incidents (e.g., accidental exposures). In resource-limited facilities, these activities should be undertaken by a visiting qualified medical physicist from the health regulatory authority.

Occupational and Public Exposure
Hazardous areas must be appropriately classified and identified. Staff members who are occupationally exposed to radiation must be monitored with personal monitoring devices such as film badges or thermoluminescent dosimeters as required by local regulations. Records of the monitoring results must be kept and made available to the staff. Protective devices such as lead gowns must be made available and worn by staff when necessary. Additional shielding and radiation monitoring are required for pregnant staff members. All X-ray equipment, including mobile equipment, must be used in rooms with adequate shielding.

CONCLUSION
For those tropical countries with remote populations or that are experiencing difficult economic situations, greater attention clearly has to be paid to the education and training of staff in addition to ensuring that proper imaging equipment is installed and maintained. Considerations such as quality management and infrastructure, personnel, equipment, radiation protection, and safety are important to ensure the proper functioning and rational use of a diagnostic radiology facility in the tropics. Regarding future needs, within any health-care system there is a spectrum of imaging requirements ranging from the most essential to the most complex. Issues to be resolved involve the clinical decision-making.
process through which diagnostic radiology examinations are produced and the optimum mixture of imaging modalities.

REFERENCES


