PROFESSIONAL ISSUES

APPROPRIATE TECHNOLOGIES IN RADIATION MEDICINE

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Abstract— **The paper discusses appropriate diagnostic and therapeutic radiology technologies in resource limited countries.**

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I. Introduction

Radiation medicine may be classified under two major categories of medical specialties, i.e. diagnosis of diseases or disorders and treatment of such diseases. The quality of these clinical services relies heavily on equipment technologies to make a diagnosis or deliver a radiation treatment. In the case of diagnostic radiology, a wide range of imaging equipment are available in the market which are designed for acquiring anatomical images of patients for diagnosis of diseases by assessing anatomical abnormalities in patients. General imaging equipment such as general radiography unit, fluoroscopy unit, mammography unit, tomography unit, general CT unit, general MRI, gamma camera, and dental X-ray unit are becoming basic and essential diagnostic imaging facilities in hospitals and clinics. In addition, a range of specialized imaging equipment is also available for diagnosis of specific types of disease with better accuracy and specificity. Advanced and specialized but expensive imaging technologies are also commercially available, which include MDCT, high field MRI, Cardiovascular and angiographic digital subtraction units, SPECT, PET-CT, and PET-MRI. These high-tech equipment have special clinical tools and functionalities for acquisition of additional information which help the diagnosis of a specific disease or improve the accuracy and specificity of a disease diagnosis, which in turn can help improving the quality of patient management procedures. Likewise, advanced but expensive radiation therapy technologies such as the latest generation of computer controlled linear accelerator with advanced on-board IGRT system and VMAT capability, robotic linear accelerator, helical tomotherapy unit, and particle therapy system are currently available. Such equipment are capable of delivering high quality radiation treatment that better meet specific clinical needs than conventional radiotherapy equipment.

In order to be able to meet all clinical needs, an adequate number of the latest generation of diagnostic and therapeutic radiology equipment is essentially required. This would be difficult to achieve in resources limited countries for a number of reasons as discussed below. A system of priority based on optimization of resources and cost effectiveness for healthcare services is often adopted in these countries. There is no simple solution to prioritization of healthcare technology as this is country specific. Different countries have different healthcare policy and priority on healthcare technology. The important consideration is how best healthcare resources can be put to optimum use.

II. Appropriate Healthcare Technology

According to a WHO discussion paper [1], there is no country in this world has yet been able to guarantee everyone immediate access to all the services that might maintain or improve their health and every country faces resource constraints of one type or another, although these are most critical in low-income countries. As different countries face different degree of resource constraints, the amount and pattern of investment and

priorities in healthcare services are different between countries. Optimization on use healthcare resources is often necessary, including use of appropriate healthcare technologies in every country.

The provision of appropriate medical devices for clinical service is an important consideration in healthcare planning, particularly in resources limited countries, where medical services are mainly provided by the government. Planning and acquisition of expensive medical devices such as radiotherapy and imaging equipment should be considered based on a set of country specific criteria. The criteria used in planning the acquisition of medical technologies may include following.

(1) Compatibility with national clinical needs

Equipment technologies should be compatible with national clinical needs. Taking radiation therapy in management of cancer patients as an example, a simple equation is that the number of therapeutic equipment needed in a country depends on the number of cancer patients required to be treated. The recommendation by IAEA on the basic machine to cancer patient ratio can be considered as a starting point [2]. In reality, a more complex equation is needed in order to be able to give a good estimate on the actual clinical requirement in a country. The type and amount of treatment and associated equipment required and the national geographical distribution of such equipment is depended on such information as national and regional cancer incidence, disease type and pattern, and staging of diseases at the time of diagnosis. These clinical data should be readily available from the national cancer registry.

(2) Cost effectiveness of equipment in patient management

Cost effectiveness is an important consideration in equipment acquisition. In countries with good primary healthcare services, a higher percentage of cancer patients can be diagnosed at earlier stages. These patients are normally treated with curative intent. Treatments of this sort are more sophisticated and the use of advanced technologies will have definite long and short term clinical advantages to the patients. In this situation, a higher proportion of radiotherapy equipment should be capable of delivery sophisticated high quality radical treatments. On the contrary, in countries with less satisfactory primary healthcare patients are often diagnosed at late stage and patients are more appropriately treated with palliative intent. Such treatments are less sophisticated and can be delivered with less complex and cheaper radiotherapy equipment. In such situation, it would be more cost effective to acquire a larger number of simple and low cost equipment to meet the case load. To what proportion between high technology and high cost equipment to simple low cost equipment should be invested would depend on case mix, case load and financial constraints of the country.

(3) Availability of staff who can be trained to make full use of the equipment

The simple formula discussed in (1) above did not take into account if qualified or appropriately trained medical doctors, medical physicists, radiation therapists and related supporting staff are available with sufficient number. One cannot take advantage or make use of the advanced features of high-tech equipment if he does not have the knowledge to use it properly. In addition, inappropriate or incorrect use of such equipment can do more harm than benefit to the patient. Healthcare planners and decision makers will have to take into account the number of staff required to operate the equipment, their qualification, competence and training requirement in the formulation for equipment acquisition.

(4) Compatibility with the local clinical operational conditions

Clinical services in hospitals are operated on an interdependent manner that aims for efficient and effective patient flow between clinical management procedures and between medical specialties. Individual services should therefore be compatible with each other in every aspect, including consistency in standard and quality between clinical procedures such that all treatment procedures are appropriate supported by other specialties, including diagnostic imaging and pathological and laboratory testing.

(5) Compatibility with local facility infrastructure

An important consideration in acquisition of medical equipment technology is the building and building services requirements for installation and operation of radiological equipment. For instance, advanced radiotherapy equipment require the availability of reliable three-phase AC power supply, air-conditioning system, coolant water and other machine specific requirements for operation. Some of them, especially high energy linear accelerators require appropriate access route for delivery to installation sites. Some of them may have special structural requirement for its delivery and installation. Provision of these building and building services can be expensive and may not even be possible in some countries or some regions of a country. On the contrary, low cost and less sophisticated radiotherapy equipment, such as Co-60 teletherapy unit and low energy linear accelerator are much less demanding in building and building services requirements hence lower installation cost.

(6) Compatibility and connectivity

For reliable and efficient operation, all medical equipment, particularly advanced radiology equipment should be electronically connected through computer

network. Achieving such connectivity in healthcare system can be a challenge in medical institutions, especially in facilities where analogue equipment are dominantly in use. The existing technological status and the long term and short term solutions for network connectivity should be considered when planning new technology for the facility.

(7) Maintaining the quality and functionality of equipment

Quality assurance is an essential measure taken by every radiotherapy centre to ensure proper and safe operation of every piece of radiotherapy equipment. Maintaining the proper operation and functionality of advanced and high cost radiology equipment can be financially and technically very demanding. Investment on manpower, expertise, appropriate test equipment and radiotherapy machine time are required to perform quality assurance testing of radiation therapy equipment. Investment of this sort is much higher on sophisticated equipment such as the latest generation of multi-modality linear accelerators as compared with that on QA of conventional radiotherapy equipment such as Co-60 teletherapy unit and single modality low energy linear accelerator.

(8) Maintenance, upgrade and replacement

Maintenance of medical equipment can be financially demanding. The typical post-warranty contract maintenance cost for an advanced radiotherapy equipment is around 10% of its capital cost. Cost cutting by in-house maintenance of complex equipment is no longer viable due to technical and proprietary limitations and high costs for replacement parts. On the other hand, contract maintenance by non-local vendor engineers on equipment installed in some developing countries, especially those in remote areas can be problematic due to difficulty for engineers and spare parts in reaching the installation sites. Furthermore, current generation of advanced medical technologies has shorter life-cycle then that of analogue equipment. This may be partly due to unavailability of key proprietary spare parts, particularly computer hardware and software. Obsolescent of modern technologies begins at around 10 years after leaving the factory. Analogue equipment with electro-mechanical control systems do not have such problems. They can be maintained by in-house engineers for a much longer life-cycle as spare parts are normally readily available from different sources. Maintenance engineers can attend to equipment fault calls without delay. When planning equipment acquisition programme, consideration should be made to balance between sophistication, quality, functionality and maintainability of high cost equipment. For developing countries with high demand for palliative treatments and limited budget, use of low cost and less sophisticated radiotherapy equipment that can be maintained by in-house engineers may be a better option.

(9) Alternative options available

In acquisition of healthcare technologies, healthcare planners and relevant healthcare professionals should consider all technology options available. They should also consider other treatment options available other than radiation therapy that may be more appropriate and effective in patient management.

III. A POSSIBLE APPROACH IN TECHNOLOGY ACQUISITION IN RADIATION MEDICINE

The above technology planning criteria and associated parameters used in assessing them are country specific and they change with time as healthcare services evolve. Hence, the formulation and policy on acquisition of equipment technologies should be reviewed regularly. To ensure that appropriate technologies are acquired that best meeting national or regional requirements in cancer treatment, a possible approach is to establish national or regional technology acquisition committee or advisory group to provide professional advice and recommendation to government on acquisition of major radiotherapy technologies. The same principle could be applied to an institutional system. The role of the expert group is to advice on all matters related to technology acquisition, including the following.

- Appropriate technologies for radiation therapy (could include technologies for diagnostic radiology)
- Implementation programme and budgetary planning
- Procurement mechanism
- Manpower and training needs
- Building and building services provisions
- Utilization monitoring and audit
- Equipment maintenance, replacement, and upgrade policy

Membership of the advisory group should include medical physicist, radiation oncologist, radiologist, radiation therapist/technologist, architect, IT expert, and representatives responsible for healthcare services and finance. Medical physicists have good knowledge on the physics and engineering principles of this type of medical devices. They are familiar with the functionality, performance, quality, limitation, connectivity and safety of such devices of different brands and models. They can contribute to the strategic planning and acquisition of such major medical devices.

IV. Conclusion

In resource limited countries, particularly those with low-income, acquisition of appropriate and cost effective medical technologies is an important measure in optimization of national resources for healthcare services. To achieve optimization in healthcare resource investment on high cost equipment such as therapeutic and diagnostic radiology equipment, consideration should be made on a number of country specific criteria. These include patient load, disease type, pattern and staging, standard of healthcare, treatment technique and intention, professional knowledge and competence of the operational staff, and financial status of the country. Correct acquisition of appropriate and cost effective medical technologies is a complex process which requires the support of professional experts of different disciplines. Medical physicists, who are familiar with the physics and engineering principles of radiological equipment, the functionality, performance and limitation of different equipment brands and models, can play a key role in the acquisition or advice others on acquisition of such equipment.

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