5. Responsibilities, Training, and Continuing Education of Human Resources

5.1 Human Resources in Radiology Services

Medical services that use radiation ***sources*** for diagnosis or treatment require specialized equipment, which must be operated by sufficiently qualified and experienced personnel. During the last two decades the complexity of some types of equipment has increased markedly and its use now requires much more extensive training and experience.

The success or failure of a procedure depends largely on the training of the human resources who prescribe and execute the procedure. Training of the staff responsible for maintenance and ***quality control*** of the equipment is also important.

It must be borne in mind that services that use ***sources*** of ***ionizing radiation*** involve physical processes that result in the irradiation of patients. In diagnostic procedures, the ***dose*** of radiation received by patients can produce long-term effects and in some instances, as in interventional radiology, even short-term effects (*24*). In radiation therapy procedures, the ***dose*** received by the irradiated tissues are large enough to destroy the tissues and induce immediate acute effects, in addition to the long-term effects.

With regard to nuclear medicine, the particular nature of this specialty and the diagnostic and therapeutic techniques associated with it make it advisable to give separate treatment to aspects relating to the human resources who work in this field.

The education of professionals and technologists should be oriented not only toward obtaining results in terms of the highest attainable quality but also toward ensuring that procedures involving ***sources*** of ***ionizing radiation*** will be carried out with the least possible harm to the health of patients. Both purposes can be fulfilled through correct selection of diagnostic or treatment methods.

Services that utilize ***sources*** of ***ionizing radiation*** can also cause harm to the health of those who work in the field, and they may also pose a threat to public health if they are not adequately designed, operated, and maintained. Those responsible for the facilities and the persons in charge of their maintenance and operation must have adequate training in elements of radiation protection so as to avoid such effects (*26*)

This chapter discusses the responsibilities of the personnel involved in radiology services and outlines the principal contents for training programs, including programs for training in maintenance. Appendix III contains several examples of the curricula for studies in these specialties in Spain.

5.2 Training and Continuing Education

In each of the various types of radiology services, it is necessary to have teams of professionals and technologists with well-defined functions and responsibilities.

It is important that the minimum education and training necessary for each professional specialty and level be established. In the case of services that use ***sources*** of ***ionizing radiation***, the regulatory agencies responsible for radiation protection should define or approve the education and training requirements for personnel working in each service, or at least for those responsible for the management of those services (*26*).

Local health systems should have the capacity to train and educate human resources. Continuous technological change makes it necessary to retrain personnel, and it is therefore important to adopt policies of continuing education in order to ensure that the professionals and technologists involved in the delivery of services have up-to-date knowledge.

Retraining is of special importance in the case of technologists, given the rapid evolution of radiological technology and the fact that technologists generally have fewer opportunities to participate in courses or educational activities after they obtain their diplomas. Updating in radiation protection should be part of such retraining.

5.3 Specific Requirements

5.3.1 Referring Physician

This is the professional who decides to request that a medical specialist perform a diagnostic or therapeutic procedure for a patient under his/her care. This physician determines whether or not the procedure is justified taking into account the benefits, at least presumptive, that it will have for the health of the patient, as well as any possible ***detriment*** that it might cause (*26*).

Due consideration should be given to any special circumstances, such as pregnancy, that might have a bearing on the analysis of whether or not the procedure is justified. In case of doubt, the referring physician should consult the radiologist about the required procedure.

Education

The referring physician should be aware of which imaging (*10*) and radiation therapy (*11*) techniques may be appropriate and the benefits and ***risks*** associated with them, particularly in special circumstances such as in pregnancy.

In the course of their university education, physicians should receive instruction in radiation biology and patient protection. They should also be given information on the relative contributions of the various ***sources*** of radiation to human ***exposure*** and on the significance that ***medical exposure*** has for the ***collective dose*** incurred by the population.

It is important to cultivate an understanding among physicians of the concept of collective detriment and benefit. During their professional lives, physicians make a great many decisions, a large number of which will contribute to an increase in the ***collective dose*** of radiation to the population. Although physicians must make each decision on the basis of considerations relating to the health of each individual patient, by adopting a collective perspective they will be better able to weigh the ***risks*** associated with radiation and will thus develop a cautious approach to making decisions about whether each procedure is justified.

Graduate courses should be offered to update physicians' knowledge, and new developments in radiation biology and radiation protection should be presented and discussed at scientific meetings. The physician should have sufficient knowledge to be able to prescribe a radiological procedure and give

specific indications regarding what is required from the specialist in imaging or radiation therapy.

5.3.2 Imaging

General practitioners and a variety of specialists, dentists, radiologists, medical physicists, diagnostic radiology technologists, and nursing personnel are all involved in the ***practice*** of imaging.

5.3.2.1 General Practitioner

At the first ***level of health care***, a physician specializing in radiology may not be available. A general practitioner with sufficient experience can fulfill the functions of this specialist. The general practitioner must possess the knowledge and experience necessary to interpret radiological images.

Education

The physician should have a good clinical background and basic knowledge of radiology, diagnostic ultrasound, and radiation protection. According to WHO, a general practitioner should perform a minimum of 200 obstetric and abdominal examinations using general-purpose diagnostic ultrasound equipment in order to be considered sufficiently trained to interpret sonograms.

5.3.2.2 Radiologist

The radiologist is responsible for all the aspects of imaging procedures. The studies should be planned individually, taking into account the characteristics of each patient and the needs expressed in the medical prescription. This is not always possible if the workload is very heavy but the radiologist should at least ensure that such planning takes place in the case of procedures that involve a relatively high ***dose*** for the patient, such as in interventional radiology.

The radiologist should be able to decide which technique is most appropriate to fulfill the objectives specified in the prescription in cases in which several techniques might be used but they would entail significantly different ***dose*** values for the patient, such as in interventional radiology.

Education

The education of the radiologist, as a specialist, should include sufficient background in general physics as well as radiation physics, dosimetry, radiation biology, both general radiation protection and patient protection, and thorough knowledge of the equipment currently available in terms of its capabilities and limitations, radiological ***risks***, and the radiological techniques that can be used with each unit. The radiologist should possess a clear understanding of ***quality assurance***. Appendix III-A shows an example of a curriculum for this specialty.

Experience is crucial, and a radiologist should not be put in charge of a radiology service unless he/she has at least one year of practical experience.

5.3.2.3 Medical Imaging Physicist

The medical physicist plays an important role in selecting equipment that is appropriate to the needs of the service; overseeing equipment maintenance, ***quality control***, and radiation protection programs; and providing advisory services and instruction on the physical aspects of radiology and radiation protection. In high-complexity services, the medical physicist is indispensable; in services of low and medium complexity, at the least, a medical physicist should be available to provide periodic advisory services (*26, 28, 29*).

Education

Medical physicists should receive comprehensive training in the physical aspects of the production of radiological images, the operation of radiology equipment, diagnostic ultrasound, nuclear magnetic resonance imaging, and the essential aspects of the techniques of obtaining and processing images, including digital techniques. The should also have knowledge of dosimetry, radiation biology, and radiation protection (*30*). In addition, they should gain practical experience in the application of ***quality control*** programs.

The practical training of the medical physicist is of considerable importance. It should last at least a year and be performed in a recognized center (*31*).

5.3.2.4 Radiological Technologist

The main responsibility of the radiological technologist is to perform radiological studies under the supervision of the radiologist. These technologists have considerable influence on the ***dose*** the patient receives

because it is they who position the patient, adjust the controls of the equipment and select the appropriate accessories.

Education

The education of the radiological technologist should include instruction in radiation physics, dosimetric quantities and units, radiation biology, and radiation protection. The technologist should acquire knowledge and experience in the use of radiology equipment of various degrees of complexity, as well as knowledge of anatomy, physiology, pathology, and radiological and image-processing techniques. Appendix III-D provides an example of the curriculum for the training of diagnostic imaging technologists in Spain, and Appendix III-E contains a draft curriculum proposed by the Spanish Association of Radiology Technologists for the professional training of radiological technologists.

It should be taken into account that services do not always have qualified radiological technologists. Some low-complexity services can manage with an equipment operator. In such cases, it is important to organize the practical training of operators so that they acquire the necessary skills and the essential knowledge of radiation protection.

5.3.2.5 Nursing Personnel

Nursing personnel participates in preparing and positioning the patient, especially in interventional radiological procedures, such as heart catheterization and angioplasty.

Education

The education of nursing personnel should include instruction in basic concepts of radiology and radiation protection.

5.3.3 Radiation Therapy

The personnel involved in radiation therapy include radiation oncologists, medical physicists, radiation therapy technologists[2], dosimetrists and nursing personnel.

[2] Called radiation therapists in some countries.

5.3.3.1 Radiation Oncologist

The radiation oncologist specializes in the use of ***ionizing radiation*** for the treatment of cancer. He/she must not only have thorough knowledge of his or her own specialty, but must also be knowledgeable about other alternatives for the treatment of cancer (surgery, chemotherapy, hormonal therapy, etc.). An essential aspect of the radiation oncologist's job is to decide which of the possible curative or palliative therapeutic procedures should be used for each patient.

Education

The radiation oncologist should possess a good general medical education and thorough knowledge of oncology. He/she should also have general knowledge of physics, radiation physics, dosimetry, radiation biology, radiation protection, and clinical dosimetry and elements of computation. In addition, the radiation oncologist should be familiar with the concepts of ***quality assurance***. Appendix III-B shows an example of a curriculum for this specialty.

It is generally agreed that the radiation oncologist should have acquired at least three years of experience in a recognized center before taking on the responsibilities of chief of a radiation therapy service.

5.3.3.2 Radiation Therapy Physicist

The radiation therapy physicist is responsible for advising on the selection of appropriate equipment to meet treatment needs; performance of acceptance testing; calibration of all ***sources*** of radiation and of dosimetric equipment; design and supervision of construction of treatment accessories such as bolus, compensators, wedges, and immobilizers; supervision of clinical dosimetry and treatment planning; establishment and supervision of a ***quality control*** program; education and training of service personnel, residents, and technologists in his/her area of expertise; advising the radiation oncologist on the appropriate treatment of patients; periodic revision of patient treatment plans; and establishment and supervision of radiation protection monitoring (*32*).

Education

The radiation therapy physicist should have a university degree in physical sciences and have special training in radiological physics applied to radiation therapy. He/she should have thorough knowledge of the physical aspects of the equipment utilized in radiation therapy and should be well versed in physical

and clinical dosimetry, radiation biology, radiation protection, instrumentation, and computation. He/she should also have knowledge of anatomy, physiology, and oncology and should have experience with ***quality control*** programs.

Practical training for radiation physicists is extremely important. It should last at least a year and be completed in a recognized center (*31*).

5.3.3.3 Radiation Therapy Technologist (radiation therapist)

The radiation therapy technologist or radiation therapist is responsible for operating the equipment and for routine positioning of the patient. He/she assists the radiation oncologist and the radiation therapy physicist in carrying out the treatment planned by them.

Education

The radiation therapy technologist or radiation therapist should have basic training in radiology similar to that of the general radiation technologist but with an orientation toward treatment with radiation ***sources***. He/she should have a good knowledge of radiological physics and the principal concepts of dosimetry, knowledge of radiation biology and of radiation protection, and a basic understanding of anatomy and oncology. An example of a proposed curriculum for this specialty is shown in Appendix III-E.

5.3.3.4 Dosimetrist

Within the field of radiation therapy, there is an increasing trend toward specialization in dosimetry.

The dosimetrist, under the supervision of the radiation therapy physicist, calculates the ***dose***, plans the treatment, and constructs treatment accessories. It is often the dosimetrist who periodically measures the ***absorbed dose*** rate from external ***sources*** and carries out other ***quality control*** tests designed by the medical physicist.

Education

The dosimetrist may be a radiation therapy technologist or a university graduate with an undergraduate degree in physics, biology, or engineering who has pursued a special course of study, which normally takes one year.

5.3.3.5 Nursing Personnel

Nursing personnel collaborate in care of patients during the different phases of treatment. In brachytherapy cases, they should assist the physician during the implant procedure and care for patients during the time they are hospitalized with implanted ***sources***.

Education

The nursing personnel who work in radiation therapy services should have knowledge of radiation protection and be trained to work in ***controlled areas***, especially when they care for patients in brachytherapy areas.

5.3.4 Nuclear Medicine

Medical specialists, medical physicists, radiochemists or radiopharmacists, nuclear medicine technologists, and nursing personnel are the personnel involved in nuclear medicine.

5.3.4.1 Nuclear Medicine Specialist

The nuclear medicine specialist is the physician responsible for utilizing in vitro or in vivo ***radionuclides*** for diagnosis or therapy, depending on the objectives of the intervention. He/she decides the course to be followed in the case of each patient in order to best meet the needs specified by the referring physician, taking into account the possibilities associated with the various techniques of diagnosis and treatment with radiopharmaceuticals and the ***doses*** of radiation involved.

Education

Nuclear medicine is a specialization which requires a solid foundation in general clinical medicine, including in particular endocrinology, mathematics, statistics, computation, physics, radiological physics, radiation biology, radiation protection, and instrumentation. The nuclear medicine specialist must have thorough knowledge of the variety of equipment available, its characteristics, its capabilities and limitations, and the radiological ***risks*** of using ***unsealed*** radioactive ***sources***. He/she should also understand the concepts of ***quality assurance***. Appendix III-C shows an example of a curriculum for this specialty.

Before taking on primary responsibility for a nuclear medicine service, the specialist should have acquired at least two years of documented experience in diagnosis and three years in treatment using nuclear medicine techniques in a recognized center.

5.3.4.2 Nuclear Medicine Physicist

The nuclear medicine physicist is responsible for the technical and dosimetric aspects of procedures carried out, ***quality control*** of the equipment and radiopharmaceuticals used, and the radiation protection in the service. He/she is also responsible for the data analysis and computational aspects of nuclear medicine.

Education

The nuclear medicine physicist should hold a university degree in physical sciences and have special training in radiological physics and nuclear medicine. He/she should have thorough knowledge of radiation dosimetry, radiation biology, radiation protection, instrumentation, statistical analysis, computation, ***quality control***, radiopharmacy, and operational aspects of radiation protection when working with ***unsealed sources***.

Practical training for nuclear medicine physicists is of considerable importance. It should last at least a year and be completed in a recognized center (*31*).

5.3.4.3 Radiochemist or Radiopharmacist

The radiochemist or radiopharmacist is responsible for the development, production, and ***quality control*** of radiopharmaceuticals used in a nuclear medicine service. The radiopharmacist is an indispensable staff member in services that have radioimmunoassay capabilities.

Education

The radiochemist or radiopharmacist should possess a university degree in chemistry or pharmacy. He/she should have completed specialized course work and practical training in handling radioactive material. He/she should also possess good knowledge of dosimetry, radiation biology, and radiation protection.

5.3.4.4 Nuclear Medicine Technologist

The role of the nuclear medicine technologist is to execute, under proper medical supervision, the preparation, administration, and measurement of radiopharmaceuticals; to perform basic maintenance of the equipment, and to help to ensure radiation protection.

Under the supervision of the medical physicist, he/she carries out dosimetric calculations and ***quality control*** tests.

Education

The nuclear medicine technologist should be a secondary school graduate with subsequent training in radiological physics and nuclear medicine. He/she should have basic knowledge of anatomy, physiology, pathology, radiation biology, radiation protection (in particular ***contamination***), statistical data analysis, and computation. Appendix III-E shows an example of a proposed curriculum for this specialty.

5.3.4.5 Nursing Personnel

The nursing personnel who work in nuclear medicine services assist physicians in the care of patients during the various stages of procedures, especially regarding inpatient care. Their contribution is especially important in the case of patients treated with radioactive materials.

Education

The nursing personnel should have good basic knowledge of radiation protection and be trained in operational aspects relating to the utilization of ***unsealed*** radiation ***sources***.

5.3.5 Maintenance

Equipment maintenance is essential to the proper function of imaging, radiation therapy, and nuclear medicine services. Correct and safe operation of the equipment is indispensable in order to ensure that the value of medical procedures using radiation ***sources*** is not undermined by errors in the procedures or uncontrolled radiological ***risks*** that can harm patients or service personnel. The greatest damage can occur when errors or flaws are not detected in time, in which case the information yielded by a diagnostic

procedure may be useless or, worse still, erroneous. The situation can be even more serious if, due to equipment failures or defects, ***doses*** different from those planned are administered to patients.

In view of these considerations, maintenance should be not only corrective but principally preventive and should be linked to ***quality control*** programs.

5.3.5.1 Maintenance Staff

The maintenance staff is responsible for keeping the equipment of the service in good working order, performing preventive maintenance and, when required, corrective maintenance. Maintenance personnel should work in collaboration with medical physicists in order to ensure that the necessary calibration or testing is performed after equipment has been worked on by the maintenance staff.

Education

Technical and professional (engineers) maintenance personnel should have completed a technical course of study or a university program in electromechanics and electricity or electronics. They should also have completed specialization courses and practical training in maintenance of the equipment for which they will be responsible. Preferably, they should be certified or accredited by the manufacturer of the equipment. They should know the basic concepts of radiological physics and radiation protection and should have a thorough understanding of the equipment's function with regard to the health of patients. With the advent of modern computerized equipment, it has become essential for maintenance personnel to also be well versed in computer technology.