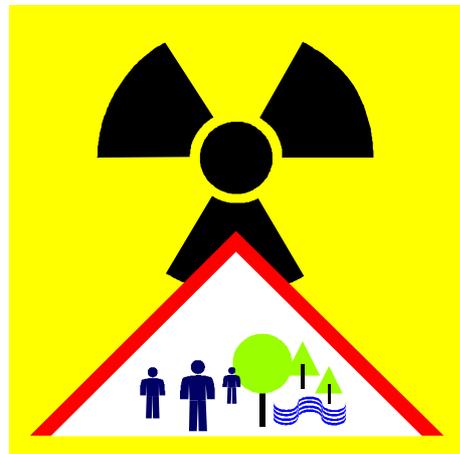


Radiation Protection 116



GUIDELINES ON EDUCATION AND TRAINING IN RADIATION PROTECTION FOR MEDICAL EXPOSURES



European Commission

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Radiation Protection 116

GUIDELINES ON EDUCATION AND TRAINING IN RADIATION PROTECTION FOR MEDICAL EXPOSURES

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FOREWORD

The EURATOM Treaty and its implementing Council Directives govern the work of the European Commission in the field of radiation protection.

The framework directive is the Basic Safety Standards Directive (BSS), on the protection of workers and the general population against the dangers arising from ionizing radiation (80/836/Euratom), as last revised by Council Directive 96/29/EURATOM of 13 May 1996 that comes into force on 13 May 2000.

In 1984, the Council of Ministers issued a Directive, supplementing the BSS, on the protection of persons undergoing medical exposures (84/466/Euratom), the so-called "Patient directive". This was revised in 1997 by Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionizing radiation in relation to medical exposure, known as the Medical Exposure Directive (MED). The MED has to be transposed into national law no later than 13 May 2000.

According to Article 7 of the Medical Exposure Directive, Member States shall ensure that the practitioner and those individuals that are mentioned in Article 5(3) and 6(3) have adequate theoretical and practical training for the purposes of radiological practices, as well as relevant competence in radiation protection. Individuals undergoing relevant training programmes may participate in practical aspects for the procedures mentioned in Article 5(3). Member States shall ensure that continuing education and training after qualification is provided and shall encourage the introduction of a course on radiation protection in the basic curriculum of medical and dental schools. Article 9 requires Member States to ensure that practitioners conducting special practices receive appropriate training.

These guidelines contain some specific recommendations for the application of the Directive and were developed with the assistance of the group of health experts established under Article 31 of the Euratom Treaty. The guidelines are not binding on Member States, and form part of a number of technical guides drawn up to facilitate implementation of the MED.

The document is structured as follows:

A general introduction providing background information and indication of the required level of training in radiation protection. This is followed by a chapter on general recommendations for training programmes in radiation protection. The third chapter gives recommendations for the establishing of credentials in radiation protection. Chapter 4 lays down recommendations for radiation protection of the patient during training programmes in health centres. Chapter 5 provides recommendations for continuing education and training after qualification and when new techniques are implemented. Chapter 6 includes recommendations for introducing the course on radiation protection in the basic curriculum of medical and dental schools and is followed by seven annexes presenting examples of specific educational objectives to be included in some of the training activities.

Suzanne FRIGREN
Director Nuclear Safety and Civil
Protection

1. Introduction

- (1) Training in general and specific training in radiation protection are widely recognised as one of the basic components of optimisation programmes for medical exposures. All the international bodies, e.g. the International Commission on Radiological Protection (ICRP), the World Health Organisation (WHO), the International Atomic Energy Agency (IAEA) etc., along with several guidelines published by the European Commission (EC), recognise the importance of education and training in reducing patient doses while maintaining the desired level of quality in medical exposures (good therapeutic treatments and images of sufficient quality for diagnosis).
- (2) The ICRP, in its publication 73 entitled “Radiological Protection and Safety in Medicine” (ICRP, 1996), states (paragraph 128) that “one important need is to provide adequate resources for the education and training in radiological protection for future professional and technical staff in medical practice. The training programme should include initial training for all incoming staff and regular updating and retraining”.
- (3) Article 7 of the Council Directive 97/43/EURATOM of 30 June 1997 on health protection of individuals against the dangers of ionising radiation in relation to medical exposure (EC, 1997) lays down requirements for education and training. Certain aspects of this Article may require some clarification and orientation for Member States and this guideline contains some specific recommendations for the application of the Directive.

Individuals undergoing medical exposures due to diagnosis or treatment are not necessarily patients but could also be healthy individuals (e.g. in screening programmes). However, for simplicity, in these guidelines they will be called patients.

- (4) This document presumes that some “adequate theoretical and practical training for the purpose of radiological practices” already exists under national requirements, together with national mechanisms to control this level of training.
- (5) Training for radiographers, medical radiological technologists, radiotherapy technologists or nuclear medicine technologists and other staff who work in areas where they may be exposed to radiation is required by Article 5(3) of the Directive. Medical physics experts are covered in Article 6(3). Maintenance engineers and other auxiliaries involved in medical exposures are not specifically mentioned, but obviously they also need training in radiation protection.
- (6) Article 9(2) of the Directive (special practices) requires Member States to ensure that practitioners conducting medical exposures of children, screening programmes and high dose procedures (interventional radiology amongst others) receive appropriate training. The recommendations of the World Health Organisation, produced at a workshop held in Munich in October 1996 (BAUML, 1997), provide a good example of the training and credentialing requirements for people involved in interventional radiology practice.

- (7) Some indication of the required level of training in radiation protection (RP) would be useful to ensure appropriate curricula in the different Member States. All staff with responsibility for medical exposures will need training in radiation protection. The following groups of professionals have been identified:

- 7.1 Diagnostic radiology specialists
- 7.2 Nuclear medicine specialists
- 7.3 Radiotherapy specialists
- 7.4 Cardiologists
- 7.5 Other medical doctors using X-ray systems (specially fluoroscopy systems) such as urologists, vascular surgeons, traumatologists, etc.
- 7.6 Dentists
- 7.7 Podiatrists
- 7.8 Radiographers and radiological technologists
- 7.9 Nurses (especially oncological nurses)
- 7.10 Technicians performing quality control in radiology installations
- 7.11 Medical physicists
- 7.12 Maintenance engineers and maintenance technicians
- 7.13 Chiropractors

- (8) Nevertheless, some specific cases could require revision, for example radiographers. In this case, the differences in contents and in hours of training between Member States are significant and some complementary efforts to harmonise this specific training will be needed. The International Society of Radiographers and Radiological Technologists (ISRRT) has published a relevant document on Professional Standards for the Education of Radiographers (ISRRT, 1996).

- (9) In certain Member States, the training of Medical Physicists could also require some support to promote actions in the specific fields of diagnostic radiology, nuclear medicine and radiotherapy, and continuing education activities. These actions should be geared to improving the training of Medical Physicists and improving the participation of these specialists in the training of medical doctors. The European Federation of Organisations for Medical Physics (EFOMP) has published relevant guidelines (EFOMP, 1996, 1998, 1999) on this issue.

It is the experience of the European Society for Therapeutic Radiology and Oncology (ESTRO), which has organised regular multidisciplinary training in radiotherapy since the mid-1980s, that support for such training is not uniform in all Member States despite evidence that standards in participating hospitals have been progressively raised.

- (10) The experience of the European Association of Radiology (EAR, 1997) and the American College of Radiology (ACR, 1997) could be valuable in this field. Guidelines for the basic aspects of continuing education programmes are needed in Europe and ACR standards can be relevant sources of information.
- (11) Practitioners and prescribers need to be considered differently for training in RP. Prescribers need a basic knowledge of some aspects of patient RP. A number of relevant guidelines have been published by the Radiology Societies (RCR, 1998), and then adapted by the European Commission and experts representing European Radiology and Nuclear Medicine (EC, 2000).

- (12) In the last few years, the European Commission Radiation Protection Actions have produced a series of guidelines concerning image quality criteria (EUR, 1996 a, b, c, d; EUR 1999), which are intended to be widely used as part of training programmes to improve the radiation protection of the patient.
- (13) The ERPET (European Radiation Protection Education and Training) courses are also a source of good training material. The European Commission sometimes publishes the proceedings of these courses (ERPET, 1997).
- (14) During the workshop held in Grado (Italy) in September 1993, sponsored by the European Commission, some relevant conclusions about training in radiation protection for medical exposures were reached (EUR, 1995). One of the conclusions was “the need and demand to improve training in radiation protection and in quality assurance. Common training programmes at European level must be continued. A practical way to make progress in the harmonisation of training could be the elaboration of specific educational objectives, as has been made within the EC VALUE Programme for radiologists and radiographers”.
- (15) In July 1998, the European Commission sent a questionnaire to Member States, professional organisations and scientific societies, requiring information on their training recommendations regarding radiation protection during medical exposures. A need for harmonisation is evident and some of the Member States asked the Commission to produce guidelines. The relevant aspects of the answers to this questionnaire have been taken into account in this document. In July 1999, a draft of this Guideline was submitted for comments to the European professional organisations and they have been also taken into account.

2. General recommendations for Training Programmes in Radiation Protection

(17) A list of topics to be included in the training programmes in RP for the different groups of professionals should be established. The following training areas could provide examples of radiation protection programmes in diagnostic radiology (VAÑO 1993):

- 17.1 The atomic structure and interaction of radiation
- 17.2 Radiological quantities and units
- 17.3 Physical characteristics of X-ray machines
- 17.4 Fundamentals of radiation detection
- 17.5 Detectors used in diagnostic installations
- 17.6 Fundamentals of radiobiology: cell, systemic and whole body responses
- 17.7 Radiation protection. General criteria
- 17.8 Operational radiological protection
- 17.9 General RP aspects in diagnostic radiology
- 17.10 Particular aspects of patient and staff RP
- 17.11 Quality control and quality assurance
- 17.12 National and European regulations and standards
- 17.13 Practical training

But these other topics should also be considered:

- Radiation effects
- Definitions of the variety of terms used for dose
- Relationship of equipment characteristics to dose and image quality
- Relationship of exposure factors to dose and image quality
- Concept of risk, comparative risk through age range and period of pregnancy
- Protocols for over exposure and accidents
- Clear communication at the appropriate level with patient, staff, comforters and carers and the public
- Diagnostic reference levels

(18) The WHO recommendations for interventional radiology (IR) require a specific second level of training in RP for these specialists (BAUML, 1997) in the following areas:

- 18.1 X-ray systems for IR.
- 18.2 Dosimetric quantities specific for IR.
- 18.3 Radiobiology: risks in IR.
- 18.4 Radiological protection of patient and staff in IR.
- 18.5 Quality assurance in IR.
- 18.6 Local and international rules concerned with IR.
- 18.7 Procedures optimisation in IR.

(19) The European Society for Therapeutic Radiology and Oncology recommends that the following topics should be included in the training syllabus for radiotherapy:

- 19.1 Radiotherapy equipment - safety and accuracy
- 19.2 Dosimetric and geometric quantities for accuracy in radiotherapy

- 19.3 Radiobiology and radiation risks
 - 19.4 Radiation treatment planning for optimising delivery of radiation dose
 - 19.5 Optimal and safe use of radionuclides in radiotherapy
 - 19.6 Radiation hazards in radiotherapy facilities
- (20) There are also British recommendations for areas of training in RP for nuclear medicine (HARDING, 89):
- 20.1 Nature of ionising radiation and its interaction with tissue
 - 20.2 Genetic and somatic effects and how to assess their risks
 - 20.3 Patient doses
 - 20.4 Quality assurance and quality control
 - 20.5 Dose limitation
 - 20.6 Pregnancy and breast feeding
 - 20.7 Unsealed sources
 - 20.8 Organisation for radiation protection
 - 20.9 Statutory responsibilities
- (21) The European Association of Nuclear Medicine (EANM) states that nuclear physicians have to be familiar with and have a knowledge of Radiological Protection (RP), amongst other topics. Nuclear physicians must have gained practical experience in patient dosimetry (diagnosis and therapy) and radiation protection (decontamination, waste disposal, staff dosimetry, etc.), amongst other topics. EANM recommends 120 hours for assessing the basic science training but “courses on radiation protection and regulation issues are not included due to different national rules”. The EANM also states that practical training has to be added to the courses and has to be formally controlled (EANM, 1997).
- (22) In addition, it is obvious that the topics to be included in training activities and the level of knowledge of the topics should be tailored to the various specialities (diagnostic radiology, radiotherapy, cardiology, dentistry, etc.) and the different kinds of work and responsibility (medical doctors, medical physicists, maintenance engineers, radiographers, etc.). At the WHO Munich meeting (BAUML, 1997), different levels of training were proposed for interventional radiology. Lists of topics and levels of knowledge were drawn up for medical doctors, radiographers, nurses and maintenance engineers. Medical Physicists should know all topics in greater detail.
- (23) The guidelines produced during recent years under the Radiation Protection Actions of the European Commission concerning image quality criteria (EUR, 1996 a, b, c, d, e) are good examples of training material for diagnostic radiology specialists, medical physicists and radiographers. The American Association of Physicists in Medicine has also published relevant guidelines concerning the teaching of clinical radiological physics to residents in diagnostic and therapeutic radiology (AAPM, 1999).
- (24) For those involved in medical exposures, table 1 presents a proposal for training areas and levels of knowledge. The areas and levels suggested in table 1 should be considered as core knowledge. More detailed additional training for some of the groups could be required. The practical application of radiological protection specific to modality should be included in "operational radiological protection". Medical physics experts should

know all the training areas at the highest level in addition to physics and all relevant aspects of quality assurance programmes.

- (25) The number of hours indicated in table 1 should be considered as being in addition to the basic training for prescribers and could be included in different training periods such as basic residency programmes and special training courses.
- (26) Training programmes should include in any case details of the procedures to be followed occurring accidental or unintended doses to patients from radiological practices.
- (27) A formal recommendation on the number of hours for the training programmes (theory and practical work) should be established. This training period will depend on the previous knowledge of radiation physics, radiobiology, etc., among the different groups of professionals in the different countries. A good tool for defining the number of hours needed for training could be the use of guidelines containing the specific educational objectives for adapting the training time to achieving these objectives.
- (28) A common core of knowledge in RP throughout Europe for the different groups of health workers in relation to their roles and responsibilities within their health care system would be desirable. It is easier to agree a list of topics for training and a catalogue of specific educational objectives than a certain number of hours of training. As part of training and in addition to attending a course self-training activities should be promoted. Appropriate training material will be required for self-training.
- (29) Practical exercises and practical sessions should be included in the programmes for training in radiation protection. A minimum of 1-2 hours practical session in a clinical installation should be included in the most simple training programmes, while 20-40% of the total time scheduled in more extensive courses should be devoted to practical exercises.
- (30) An important aspect of these training activities is the availability of training material. Books, slide collections, videos, interactive CD-ROM, are scarce and not always adapted to the level needed in the different courses. The EC will encourage publication of the content of the different training courses and promote the preparation of specific training material for a set of basic courses (e.g. basic training in radiation protection for cardiologists). Profiting from the experience of the different European countries in this field could also be very positive. The EFOMP has co-sponsored the EC action EMERALD dedicated to education and training in Medical Physics (information available from EFOMP, <http://www.efomp.org/index.html>).
- (31) The lecturers must have previous experience in radiation protection in medical installations and in practical work in a clinical environment. Installations where practical training is provided should be medical installations and not only laboratory or simulation exercises.
- (32) Paediatric radiology, screening mammography and computed tomography also require some specific training in RP for radiologists and radiographers involved in these examinations. Some relevant guidelines for quality assurance for paediatrics have been published (EUR, 1996b; COOK, 1998, NCRP, 1981). Some proposals for specific educational objectives are included as examples in these guidelines.

- (33) Some special practices like interventional radiology require, as recommended by the WHO (BAUML, 1997), a second level of specific training in radiation protection in addition to the general level received by diagnostic radiology specialists.
- (34) In addition, some special consideration is required in the case of medical doctors (non-radiologists) using fluoroscopy X-ray systems regularly (urologists, vascular surgeons, traumatologists, etc.). A basic training in RP should be defined as indicated in table 1 (MD column).
- (35) In some states in the USA, these doctors require specific credentialing in radiation protection (WAGNER, 1998) and in Europe a similar system should be established.
- (36) In September 1999, The “Institut National des Sciences et Techniques Nucléaires” organised in Saclay (France) an International Conference on “Radiation protection: What are the future training needs?” A list of training modules on radiation safety has been agreed for the medical field (see Annex).

3. Recommendations for the credentialing process in radiation protection

- (37) A system for credentialing RP training programmes should be established at national or regional level. This process should be undertaken by the Regulatory Authority, with the help of Academic Institutions (Universities) and scientific or professional societies. A register of accredited bodies should be established. For Medical Physicists, EFOMP has laid down a well-structured system of recommendations for education and training, continuing professional development and requirements for National Registration Schemes (EFOMP, 1998).
- (38) The minimum requirements for credentialing a training programme should consider all the aspects involved: enough administrative support, guarantees for the archiving of files, diplomas, etc., for a minimum number of years (20 years), enough didactic support (classroom, audio-visual support, etc.), teachers qualified in the topics to be imparted and with experience in hospital medical physics work, instrumentation for practical exercises, availability of clinical installations for practical sessions, etc.
- (39) Various alternatives should be proposed for credentialing different professionals with different duties and responsibilities (examination at the end of the course, residency, continuous evaluation, etc.).
- (40) Basic details should be given in the diplomas or certificates received by people attending a training programme in RP: centre conducting the training, number of accredited training hours, process of credentialing: examination or other form of assessment, date of the training, name of the academic staff with responsibility for the training programme, etc.
- (41) The second level of training in RP for Interventional Radiology, recommended by the WHO (BAUML, 1997) would also require a specific accreditation, and the same applies to the special case of medical doctors using fluoroscopy on a regular basis.

4. Recommendations for radiation protection of the patient for individuals undergoing training programmes in health centres

- (42) Patient RP requires special consideration during the training of residents and radiographers. The criteria of justification and optimisation should be applied carefully and all the procedures should be performed under the responsibility of a senior specialist.
- (43) Some specific recommendations could also be made for planning practical RP training in medical installations (e.g. X-ray systems must remain in operative condition after the training sessions) if patients are involved, simple procedures - low doses - must be selected; It is not permitted to give some additional irradiation to the patient just for training purposes.
- (44) In the case of high patient dose procedures (interventional and some vascular diagnostic procedures), strict patient dose control should be performed to guarantee that no significant additional doses due to the training are imparted. In paediatrics, screening mammography and computed tomography also no significant additional doses due to training should be imparted.

5. Recommendations for continuing education and training after qualification and on implementation of new techniques

- (45) The ACR Continuous Medical Education (CME) Standard (for physicians and medical physicists) requires a minimum of 150 hours of approved education in category 1 and 2 every three years (to be renewed in a three year cycle) (ACR, 1997). The experience of the European Association of Radiology (EAR, 1997) also is relevant for this topic.
- 45.1 Category 1 (designated by ACR or other recognised organisations). The minimum number of hours is 60. Accredited residencies and fellowships up to 50 hours per year can be included.
- 45.2 Category 2. The maximum number of hours allowed is 90. Activities accepted: medical meetings, lectures, course syllabuses, study of authoritative medical literature, teaching radiology-related services to medical students, preparation and publication of scientific papers, presentation of papers, courses, or scientific exhibits, clinical consultations, use of computer-assisted learning materials designed to enhance patient care, review of manuscripts for peer-reviewed journals and review of abstracts for scientific meetings.
- (46) Some training directed towards continuous education in RP should be included (together with practical education, particularly on the installation of new equipment), the extent depending on the kind of work. A radiographer, radiotherapist or medical physicist would need more time dedicated to continuous education in RP than a dentist, for example.
- (47) This continuous training education in RP should be promoted by the Regulatory and Health Authorities, and some basic courses should, where necessary, be organised by the health centres, academic institutions or professional and scientific societies. In this field, the actions of the European Society of Radiology (ESR), the European Society for Therapeutic Radiology and Oncology (ESTRO), the European Federation of Organisations for Medical Physics (EFOMP), the European Association of Nuclear Medicine (EANM) and the International Society of Radiographers and Radiological Technologists (ISRRT) are also relevant.
- (48) Whenever a new radiation equipment is introduced in a hospital or clinic, specific training should be provided before clinical use of the system and the participation of the engineers of the firm supplying the system should be required. This training should be part of the commissioning process of the new radiation system. It is important to consider the responsibility of the supplier for the availability of full and understandable instructions in the local language.
- (49) Specific training for new people arriving at installations practising medical exposures should be also provided before the clinical work begins.
- (50) Additionally, whenever a new technique is implemented in a centre, prior training for staff should be required. In this case, the training should be provided at another centre with previous experience in the technique, taking into account the considerations mentioned in the previous section on “Recommendations for radiation protection of the patient for individuals undergoing training programmes in health centres”. A certain

number of examinations and/or procedures which should be performed under the control of an experienced physician could be considered in some cases.

6. Recommendations regarding the course on radiation protection in the basic curriculum of medical and dental schools

- (51) According to the EC Medical Exposure Directive (MED), “Member States shall encourage the introduction of a course on radiation protection in the basic curriculum of medical and dental schools”.
- (52) This training should include all the basic RP knowledge needed by the prescriber (a medical doctor, dentist or other health professional who is entitled to refer individuals for medical exposure to a practitioner, in accordance with national requirements). Prescribers should be educated in the basic aspects of radiation protection, specially justification and optimisation. Article 5 of the MED states that both the prescriber and the practitioner shall be involved as specified by Member States in the justification process at the appropriate level. Article 4(1) is dealing with optimisation and Article 4(3) with the right choice of equipment. This basic training should be independent of the complementary training received where some of the doctors become practitioners.
- (53) These courses should have a different orientation and content for medical and dental students. In medical schools, the main topics should be the general aspects of patient protection such as biological effects, justification of medical exposures, risk benefit analysis, typical doses per examination, etc., together with some basic knowledge of the advantages and disadvantages of the use of ionising radiation in medicine (including objective information about radioactive waste and its safe management). Medical students do not need specific training in the design and operation of the medical installations required for radiodiagnosis, nuclear medicine and radiotherapy. This specific RP training will form part of their training programme as residents to become specialists.
- (54) The case of dental schools is different. In addition to the basic aspects mentioned for medical schools, the course on radiation protection should also include all the specific training for the safe operation of X-ray systems for diagnostic purposes, such as the principles of X-ray tube operation, radiographic imaging, film processing, quality assurance programmes, occupational and patient dose control, etc.
- (55) Assuming that a basic knowledge of radiation physics forms part of preclinical training (basic Medical Physics or equivalent), the general part of the recommended RP course could concentrate on topics addressing patient protection. A possible outline could be the content of the ICRP 73, Radiological Protection and Safety in Medicine (ICRP, 1996).

- 55.1 Introduction
- 55.2 The Quantification of Radiation Dose and Risks (including radiation effects)
- 55.3 The Framework of Radiological Protection
- 55.4 The Justification of a Practice
- 55.5 The Optimisation of Protection

- 55.6 Individual Dose Limits
- 55.7 Practical Methods of Protection
- 55.8 Operational Guides and Reference Levels
- 55.9 Accidents and Emergencies
- 55.10 Institutional Arrangements

(56) Some practical sessions and seminars could be focussed on the following topics:

- 56.1 Justification of medical exposures for some specific diagnosis (advisability of simple radiography or CT; consideration of alternatives such as ultrasound or magnetic resonance, etc.).
- 56.2 Responsibility of the referring physician regarding medical exposure.
- 56.3 Different levels of risk as a function of the age of the patients.
- 56.4 Different levels of doses for different kinds of procedures (chest, abdomen and spine examinations, CT, nuclear medicine examinations, etc.).
- 56.5 Recommendations addressed to pregnant and breast feeding patients who need radiological examinations (with X-ray and with radionuclides).
- 56.6 Importance of diagnostic reference levels in optimisation programmes and in standard risk estimation.
- 56.7 Why and how a hospital produces radioactive waste and the safe management of this kind of waste.
- 56.8 Practical examples of how to inform patients (and helpers) about the risk of medical exposure. Comparison with other kinds of risks.

(57) Part of this training could be merged with the basic training in radiology during the clinical period. This should have as part of its aim “to explain basic radiation protection in the light of EU Directive 97/43/Euratom of 30 June 1997” (ERIKSON, 1998). The problem of educating radiologists in radiation protection is a separate postgraduate issue.

(58) A basic radiation protection course should also be introduced in nursing and podiatry schools.

(59) The duration of this RP training should be between 20 and 40 hours, assuming a prior knowledge of radiation physics. A percentage of 20-30% should consist of practical or seminar sessions analysing typical cases presented in clinical practice.

(60) This training in RP should be encouraged and provided at the end of the preclinical period or during the clinical period.

ANNEXES

These annexes present only examples of topics to be included in some of the training activities. Their coverage and level will obviously depend on the kind of job and responsibility. These specific educational objectives will be of interest to different groups of professionals (radiologists and radiographers involved in interventional procedures, mammography, or in paediatric radiology; some examples are also presented for paediatric nuclear medicine and for radiotherapy). Similar catalogues of specific educational objectives for other techniques (e.g. Computed Tomography, Digital Radiology, etc.) should be drawn up.

1. Outline for specific training in Radiation Protection for Interventional Radiology

- (1) As an example of the usefulness of specific educational objectives in preparing training activities, some items defined by a group of DIMOND experts (VAÑO, 1997), for areas proposed during the WHO meeting in Munich, are presented:
- (2) X-ray systems for interventional radiology.
 - 2.1 To explain the effect of a high additional filtration (e.g. copper filters) on conventional X-ray beams.
 - 2.2 To explain the operation of continuous and pulsed X-ray emission modes.
 - 2.3 To explain the benefits of the grid controlled X-ray tube when using pulsed beams.
 - 2.4 To explain road mapping.
 - 2.5 To explain temporal integration and its benefits in terms of image quality.
 - 2.6 To analyse the changes on the dose rate when varying the distance from image intensifier to patient.
- (3) Dosimetric quantities specific for interventional radiology.
 - 3.1 To define the dose-area product (DAP) and its units.
 - 3.2 To define entrance dose and entrance dose rate in fluoroscopy.
 - 3.3 To discuss the correlation between surface dose and DAP.
 - 3.4 To discuss the relationship between DAP and effective dose.
 - 3.5 To correlate the dose upon entry into the patient with the dose at the exit surface and the dose at the intensifier input surface.
- (4) Radiological risks in interventional radiology.
 - 4.1 To describe deterministic effects which may be observed in IR.
 - 4.2 To analyse the risks of deterministic effect induction as a function of the surface doses received by the patients.
 - 4.3 To analyse the relationship between received doses and deterministic effects in the lens of the eye.
 - 4.4 To be aware of the likely time intervals between irradiation and occurrence of the different deterministic effects, the required follow-up and control of patients.

- 4.5 To analyse the stochastic risks in interventional procedures and their age dependence.
- (5) Radiological protection of the staff in interventional radiology.
 - 5.1 To comment on the most important factors which influence staff doses in IR laboratories.
 - 5.2 To analyse the influence of the X-ray C-arm positioning on occupational doses.
 - 5.3 To analyse the effects of using different fluoroscopy modes on occupational doses.
 - 5.4 To analyse the effects of using personal protection (e.g. leaded aprons, gloves, eyeglasses, thyroid protectors, etc.).
 - 5.5 To analyse the benefits and drawbacks of using articulated screens suspended from the ceiling.
 - 5.6 To understand the importance of the suitable location of personal dosimeters.
- (6) Radiological protection of patients in interventional radiology.
 - 6.1 To analyse the correlation between fluoroscopy time and number of images taken in a procedure and dose received by patients.
 - 6.2 To discuss the effects of the focus to skin distance and patient image intensifier input distance.
 - 6.3 To analyse the dose reductions attainable by modifying the image rate in cine or in digital acquisition.
 - 6.4 To give typical examples of patient entrance dose value per image in different procedures.
 - 6.5 To analyse the effect of using different magnifications in the patient dose.
 - 6.6 To discuss the parameters which should be recorded in the patient history regarding (or with reference to data on) the doses received.
- (7) Quality assurance (QA) in interventional radiology.
 - 7.1 To discuss the difference between parameters that usually do not downgrade with time and those which could require periodical control.
 - 7.2 To discuss the importance of establishing simple criteria to compare doses at the patient or intensifier entrance in different situations.
 - 7.3 To note the importance in QA programs of the periodical control of patient dose and its comparison with reference dose levels.
- (8) Local and international rules for interventional radiology.
 - 8.1 To discuss the different national regulations which apply in IR installations.
 - 8.2 To describe the international recommendations for IR (WHO, IAEA, ICRP, EC, etc.).
 - 8.3 To provide information on the international recommendations concerning the limitation of high-dose modes.
- (9) Procedure optimisation in interventional radiology.
 - 9.1 To note the importance of optimisation in IR radiation procedures.

- 9.2 To discuss the importance of reference levels related to the patient dose at local, national and international levels.
- 9.3 To analyse the importance of periodical patient dose control in each room.
- 9.4 To discuss the possibility of using different C-arm orientations during long procedures in which the threshold for deterministic effects may be attained.
- 9.5 To analyse the importance of recording the dose imparted to every patient.

2. Outline of specific educational objectives for mammography

(1) X-ray and image systems for mammography.

- 1.1 To discuss the effect of the generator in the quality and intensity of the X-ray beam (power, wave form, etc.).
- 1.2 To analyse the importance of the generator power in exposure times.
- 1.3 To describe the several focus sizes for the same X-ray tube and the differences between the power associated with each of them.
- 1.4 To discuss the focus size to be employed with the conventional and magnification techniques.
- 1.5 To discuss the X-ray beam characteristics employed in mammography.
- 1.6 To discuss the effect of the anode type on the quality and intensity of the X-ray beam.
- 1.7 To discuss the effect of the filter type on the quality and intensity of the X-ray beam.
- 1.8 To describe the different anode/filter combinations that are available in modern X-ray mammography units.
- 1.9 To explain the employment of different anode/filter combinations depending on breast features.
- 1.10 To describe the most important grid parameters (grid ratio, number of grid lines/cm, interspace material and focus distance).
- 1.11 To discuss the use of the grid and its dependence on breast size and breast composition.
- 1.12 To describe the basic elements and performance of automatic exposure control (AEC).
- 1.13 To discuss the AEC sensor position with regard to breast size.
- 1.14 To analyse the most important problems related to the routine use of AEC.
- 1.15 To discuss the effect of breast compression on X-ray beam attenuation.
- 1.16 To describe the film parameters (base+fog, speed, contrast, average gradient and latitude).

(2) Dosimetric quantities specific for mammography.

- 2.1 To define the entrance surface air-kerma (ESAK).
- 2.2 To define backscatter and the backscatter factor.
- 2.3 To define the entrance surface dose (ESD).
- 2.4 To define the average glandular dose (AGD).
- 2.5 To establish the relation between ESAK and AGD.
- 2.6 To describe the breast features that affect the ESAK-AGD relationship.
- 2.7 To describe the X-ray beam parameters that affect the ESAK-AGD relationship.

- 2.8 To explain the methods for estimating the ESAK and AGD values.
- (3) Radiobiology: risks in mammography.
- 3.1 To describe the increment in the stochastic effects as a function of the AGD.
 - 3.2 To discuss the factors proposed by the ICRP-60 for stochastic effects in the breast (fatal and curable cancers).
 - 3.3 To discuss the increment in organ dose with breast size and breast composition.
- (4) Radiological protection of staff in mammography.
- 4.1 To comment on the most important factors that influence staff doses in mammography installations.
 - 4.2 To analyse some typical values of occupational dose for mammography installations with and without protection screen.
 - 4.3 To correlate the occupational dose values with workload.
- (5) Radiological protection of patients in mammography.
- 5.1 To analyse the effect of mammography equipment (generator, FFD, anode/filter combination, dose rate, etc.) on the dose to the patient.
 - 5.2 To analyse the effect of the radiological technique (kV, grid, type of view, optical density of the film, exposure time, etc.) on the dose received by the patient.
 - 5.3 To discuss the effect of breast compression on dose values.
 - 5.4 To discuss the influence of the film-screen combination on dose values.
 - 5.5 To discuss the influence of developer temperature and extended processing time on dose values.
 - 5.6 To analyse the typical ESAK and AGD values for an average breast.
 - 5.7 To analyse the reference values for the ESAK and AGD.
 - 5.8 To discuss the potential dose reduction to be obtained with digital mammography.
- (6) Image Quality in mammography.
- 6.1 To discuss the more relevant features of a mammography image by comparing with the radiological images from other types of examination.
 - 6.2 To discuss the effect of the X-ray equipment characteristics (generator, FFD, anode/filter combination, focus size, etc.) on the quality of the mammography image.
 - 6.3 To point out the importance of “low exposure times”.
 - 6.4 To analyse the effect of the radiological technique (kV, grid, type of view, optical density of the film, compression, patient positioning etc.) on image quality.
 - 6.5 To discuss the influence of the film parameters (contrast, average gradient, latitude) on image quality.
 - 6.6 To discuss the influence of developer temperature and extended processing time on image quality.
 - 6.7 To describe the several methods for evaluating image quality.

- 6.8 To discuss the limiting values proposed for the parameters associated with image quality.
 - 6.9 To point out the image quality criteria for clinical mammography images.
 - 6.10 To discuss the potential improvement in image quality to be obtained with digital mammography.
- (7) Quality assurance in mammography.
- 7.1 To discuss the difference between parameters that usually do not downgrade with the passing of time and those which could do and require periodical control.
 - 7.2 To discuss the additional QA requirements for mammography screening.
 - 7.3 To analyse the importance of periodic control of all components of the X-ray equipment.
 - 7.4 To analyse the importance of periodic control of the processor.
 - 7.5 To analyse the importance of periodic control of the film/screen system.
 - 7.6 To analyse the importance of periodic control of the viewing box.
 - 7.7 To note the importance in QA programmes of the periodical control of patient dose and its comparison with reference dose values.
 - 7.8 To analyse the importance of periodical image quality control.
 - 7.9 To analyse the importance of the periodical evaluation of image quality based on clinical criteria.
- (8) Local and international rules and recommendations concerning mammography.
- 8.1 To discuss the national and European recommendations which apply in mammography installations.
 - 8.2 To discuss some examples of accreditation programmes for mammography.
 - 8.3 To analyse the content of the guidelines published by the EC which apply to mammography.
- (9) Procedure optimisation in mammography.
- 9.1 To note the importance of optimisation in mammography.
 - 9.2 To discuss the importance of using the reference dose values at the local, national and international levels.
 - 9.3 To analyse the importance of recording periodically the dose values and radiographic techniques.
 - 9.4 To point out the need for frequently reviewing the tolerances or limiting values proposed in the quality control protocols.

3. Outline of specific educational objectives for paediatric radiology

- (1) General, equipment and installation considerations.
- 1.1 To justify the requirements concerning the power of the generator and its relationship with the need for short exposure times (3 milliseconds).
 - 1.2 To explain the convenience of high frequency generators in relation to the accuracy and reproducibility of exposures in paediatrics.

- 1.3 To discuss the advantages and limitations of automatic exposure control devices in paediatrics.
- 1.4 To justify the specific technical requirements of the automatic exposure control devices for paediatrics.
- 1.5 To explain that careful manual selection of exposure factors usually results in lower doses.
- 1.6 To explain the design aspects to be considered in paediatric X-ray rooms for improving the child's cooperation (control panel with easy patient visibility and contact, etc.).
- 1.7 To discuss the advantages and limitations of fast film-screen combinations.
- 1.8 To discuss the advantages of using low-absorbing materials in cassettes, tables, etc.
- 1.9 To analyse the limited improvement in image quality when using the antiscatter grid in paediatrics and the increase in patient dose.
- 1.10 To analyse the specific technical requirements of antiscatter grids for paediatrics.
- 1.11 To explain how the antiscatter grid should be removable in paediatric equipment, particularly fluoroscopic systems.
- 1.12 To explain the convenience of using image intensifiers with high conversion factors for reducing patient dose in fluoroscopic systems.
- 1.13 To justify the convenience of specific kV-mA dose rate curves for automatic brightness control in fluoroscopic systems used for paediatrics.
- 1.14 To explain that it is preferable not to use the ABC unless there is an automatic cut-off device.
- 1.15 To discuss the importance of using specific technical radiographic parameters for CT examinations in paediatrics (lower mAs than for adults, and lower kV in some cases).
- 1.16 To analyse the special problems with the use of mobile X-ray units in paediatrics.
- 1.17 To explain the advantages and disadvantages of under-couch and over-couch fluoroscopy units for paediatrics.
- 1.18 To discuss the advantages and role of pulsed fluoroscopy.
- 1.19 To compare conventional and digital equipment and the role/use of frame-grab technique in digital imaging.
- 1.20 To discuss value of cine playback (digital) and video playback (digital/conventional fluoroscopy) in screening examinations.
- 1.21 To discuss the role of additional tube filtration.

(2) Reduction of exposure

- 2.1 To analyse the most frequent causes of repeating films in paediatrics - reject analysis, audit and feedback.
- 2.2 To discuss how immobilisation can reduce the repeating film rate.
- 2.3 To analyse the different immobilisation devices available for paediatric radiology to make application atraumatic. The role of simple aids such as sticky tape, sponge wedges and sand bags.
- 2.4 To explain how short exposure times can improve image quality and reduce the number of films repeated.

- 2.5 To explain the inconvenience of using mobile X-ray units for paediatrics and the difficulty in getting short exposure times.
- 2.6 To explain the importance of having radiographers with specific training in paediatric radiology.
- 2.7 To discuss the importance of gonadal protection in paediatric radiology and value of having various sizes and types.
- 2.8 To analyse the importance of the collimation (in addition to the basic collimation corresponding to the film size) in paediatric patients, particularly window protection for hips and lateral collimation devices for follow-up scoliosis.
- 2.9 To discuss the importance of the correct patient positioning and collimation, particularly for excluding the gonads from the direct beam.
- 2.10 To discuss the importance of establishing whether adolescent girls might be pregnant when abdominal examinations are contemplated.
- 2.11 To discuss use of the 28 and 10 day rule in children over 12 years or younger if relevant.
- 2.12 To discuss the fact that motion is a greater problem in children and could require specific adjustment of radiographic techniques.
- 2.13 To discuss the importance of a proper consultative relationship between the referring physician and the radiologist. Role of agreed protocols and diagnostic pathways.
- 2.14 To discuss some examples of radiological examination of questionable value in children (like some follow-up chest radiographs in simple pneumonia, abdominal radiographs in suspected constipation, etc.).
- 2.15 To explain that the repetition of a radiological examination in paediatrics should always be decided by the radiologist.
- 2.16 To discuss the convenience of using appropriate projections for minimising dose in high risk tissues (PA projections should replace AP where possible for spinal examinations).
- 2.17 To discuss the convenience of having additional filters available to enable them to be easily changed (1 mm Al; 0.1 and 0.2 mm Cu should be available).
- 2.18 To discuss the value of having a dedicated paediatric room or complete sessions dedicated to paediatric radiology. Experienced staff who can obtain the child's confidence and cooperation in a secure and child-friendly environment are of paramount importance in reducing radiation doses in paediatrics.
- 2.19 To discuss the importance of having specific referral criteria, e.g. for head injury where the incidence of injury is low.
- 2.20 To discuss referral criteria for all X-ray examination of children, especially those which may be age-related, e.g. scaphoid not ossified, below age of 6 years, nasal bones cartilaginous below age of 3 years.
- 2.21 To discuss high kV techniques.
- 2.22 To explain the value of using long focus patient distances.
- 2.23 To explain the importance of using the light beam diaphragm to move the patient into position rather than screening during overcouch fluoroscopy procedures.
- 2.24 To discuss the role of audit and quality assurance in maintaining or improving image quality and dose.

(3) Risk factors

- 3.1 To discuss the fact that longer life expectancy in children means a greater potential for manifestation of possible harmful effects of radiation.
- 3.2 To consider that the radiation doses used to examine young children should generally be smaller than those employed in adults.
- 3.3 To explain that the risk factor for cancer induction in children is between 2 and 3 times higher than for adults, with emphasis on the developing breast and gonads and the more widespread distribution of red bone marrow in the developing skeleton.
- 3.4 To discuss the risk factor for genetic effects in children.
- 3.5 To compare the risk factors for radiological examination in children with other common risks like travelling by air or by car.
- 3.6 To relate with the natural occurrence of congenital abnormalities.
- 3.7 To relate with the natural incidence of cancer.

(4) Patient dosimetry. Reference dose values.

- 4.1 To explain the specific difficulties of measuring patient doses in paediatrics.
- 4.2 To discuss the dosimetric techniques available for patient dosimetry in paediatrics.
- 4.3 To discuss how patient dose values are related to patient size.
- 4.4 To analyse some typical patient reference dose values in paediatrics and their relation with patient size.
- 4.5 To analyse the reference dose values available for paediatrics.
- 4.6 To discuss how to use reference dose values in paediatric radiology.

(5) Protection of personnel and parents

- 5.1 To analyse the possibility of parents cooperating in the radiological examination of their children and the precautions to be taken.
- 5.2 To clarify that the parents' exposure in this situation can be considered as a medical exposure but that optimisation criteria must be applied.
- 5.3 To highlight that the parents or helpers should know exactly what is required of them.
- 5.4 To explain that pregnant women should not be allowed to help during paediatric examinations.
- 5.5 To explain the importance of using lead aprons and lead gloves (if the hands are in the direct radiation field) in these situations.

(6) European guidelines and international recommendations

- 6.1 To explain the content of the European Guidelines on Quality Criteria for Diagnostic Radiographic Images in Paediatrics.
- 6.2 To take into account the existence of relevant documents published by the ICRP, NCRP and WHO concerning radiation protection in paediatric radiology.

4. Addendum for paediatric nuclear medicine

Some of the previous objectives could also be of interest for nuclear medicine specialists performing paediatric procedures. Some additional items proposed by the EANM are as follows:

(1) General considerations

- 1.1 To explain the importance of having nuclear medicine technologists with specific training in paediatric radiology.
- 1.2 To discuss the fact that motion is a greater problem in children and could require specific adjustment of nuclear medicine techniques.
- 1.3 To discuss the importance of a proper consultative relationship between the referring physician and the nuclear medicine specialist.
- 1.4 To explain that the repetition of a nuclear medicine examination in paediatrics should always be decided by the nuclear medicine specialist.

(2) Risk factors

- 2.1 To compare the risk factors for nuclear medicine examinations in children with other common risks like travelling by air or by car.

(3) Patient dosimetry. Reference dose values.

- 3.1 To discuss how to use the reference dose values in paediatric nuclear medicine.

(4) Protection of personnel and parents

- 4.1 To explain how to deal with radioactivity in body fluids, especially urine.

(5) Reduction of exposure

- 5.1 To discuss how to determine the amount of activity to be administered to paediatric patients.
- 5.2 To discuss how to enhance elimination of radiopharmaceuticals in order to reduce exposure.

5. Outline of specific educational objectives for radiotherapy

The practice of radiation oncology (radiotherapy) encompasses the clinical care of patients as well as the technical aspects of radiotherapy. Benefits to patients accruing from radiotherapy depend upon the accurate delivery of high doses to the tumour with doses to normal tissues being kept to a minimum. In addition to these patient-centred aspects of radiation protection in radiotherapy, appropriate measures must also be taken to reduce the amount of radiation to staff and the general public to as low a level as is reasonably attainable.

In order to achieve these aims, a broad basic training is required in all of the disciplines involved in the delivery of ionising radiation. ESTRO has recommendations for core curricula for the disciplines involved, and this outline lists the elements from these curricula which relate specifically to radiation protection.

It is important to reiterate that the extent of training required will depend upon the existing levels of knowledge and training of different groups of professionals in physics, radiobiology etc., and this may vary across the Member States.

(1) Radiotherapy equipment - safety and accuracy.

- 1.1 To show that the principles of operation and details of construction of therapy X-ray generators, including treatment head, are designed for safe and accurate delivery of radiation to the target volume with minimal collateral radiation dose.
- 1.2 To discuss how filtration and factors affecting output of kV X-ray units determine the radiation dose to skin and target volume.
- 1.3 To discuss how the construction of cobalt-60 units and methods of safety control minimise the risk of radiation accidents.
- 1.4 To describe the production of MV X-rays in a linear accelerator, and the arrangements for limiting X-ray head leakage.
- 1.5 To describe kV X-ray applicators, electron applicators, conventional linear accelerator collimators, multi-leaf collimators, the effect of collimators on penumbra size, shielding materials and dose under shielding materials, and the relevance in restricting radiation dose to the target volume.
- 1.6 To describe equipment controls and interlocks, and select/confirm systems, and their role in hazard control.
- 1.7 To explain the role of commissioning measurements and quality control checks in determining the accuracy of radiation dose delivered to the patient.
- 1.8 To discuss the merits of equipment and limitations of use with respect to the optimal and safe delivery of radiation to the patient.
- 1.9 To discuss the merits of verification in respect of the information needed to ensure accurate and safe delivery of radiation to the treatment volume.

(2) Dosimetric and geometric quantities for accuracy in radiotherapy

- 2.1 To discuss the use of percentage depth dose curves, backscatter and peak-scatter factors, tissue phantom ratios, tissue standard factors and equivalent squares in determining the radiation dose delivered to a patient.
- 2.2 To discuss the role of beam geometry, magnification and beam penumbra in determining the extent of the radiation field which treats a patient.
- 2.3 To explain the definition of field size and its use in ensuring correct coverage of the target volume.
- 2.4 To explain the variation of depth-dose characteristics with energy and to relate these to the optimum choice of energy in delivering radiation to a patient.
- 2.5 To explain the general features of isodose charts and their dependence upon FSD and energy with regard to ensuring the adequate and homogeneous irradiation of the target volume.
- 2.6 To describe the acquisition and use of beam data for radiotherapy treatment planning and to analyse the limitations of the algorithms used.
- 2.7 To explain calibration protocols and the uncertainties in the calibration process and to relate these to the overall uncertainty of patient radiation dosage.

(3) Radiobiology and radiation risks

- 3.1 To discuss the justification and use of radiotherapy in malignant and benign disease.
- 3.2 To contrast the use of external beam therapy and brachytherapy in the treatment of disease and to discuss the relative benefits of both modalities to the patient.
- 3.3 To relate the response to radiation at the molecular and cellular level, including cellular injury and cell survival curves, to the macroscopic response of tissue to radiation.
- 3.4 To discuss the response of tumours and normal tissue to therapeutic levels of radiation, including dependence on fractionation, dose rate, radiosensitisation, reoxygenation.
- 3.5 To consider radiation reactions - early and late.
- 3.6 To discuss the role of radiobiological modelling including linear-quadratic model in explaining the effects of radiation injury to tissues.
- 3.7 To discuss therapeutic ratio and its role in optimising dose delivered to patients.
- 3.8 To discuss the effects of radiation on the embryo and fetus, leukaemogenesis and carcinogenesis, genetic and somatic hazards for exposed individuals and populations.
- 3.9 To explain the assessment of the efficacy of radiotherapy and its role in the justification of radiation treatment.

(4) Radiation treatment planning for optimising delivery of radiation dose

- 4.1 To describe the delineation of target volumes including ICRU50 and ICRU62, and its role in optimising radiation treatment.
- 4.2 To contrast fixed-SSD and isocentric radiotherapy, and to discuss the relative benefits of the two methods.
- 4.3 To describe beam modification including oblique incidence, inhomogeneities, wedges, compensators and interface effects in the context of achieving accurate, homogeneous irradiation of the target volume.
- 4.4 To discuss the combination of fields to produce homogeneous irradiation of the target volume.
- 4.5 To discuss how 3-D treatment planning and optimisation can be used to limit the radiation exposure of normal tissues.
- 4.6 To discuss how the use of conformal radiotherapy can optimise the irradiation of the target volume with respect to normal tissue.
- 4.7 To explain how treatment verification and in-vivo dosimetry can enhance the accuracy of the dosage and targeting of the radiation field.
- 4.8 To explain how Intensity Modulated Radiotherapy (IMRT) can be used to limit the radiation dose delivered to vulnerable organs.
- 4.9 To explain how stereotactic radiotherapy can limit collateral radiation damage.
- 4.10 To explain the role of Monte Carlo treatment planning in enhancing the accuracy of dose estimation.
- 4.11 To discuss the role of different imaging modalities in radiotherapy including CT and MRI in enhancing the accuracy of target volume delineation.
- 4.12 To describe methods of patient alignment and immobilisation and their role in enhancing the geometric accuracy of dose delivery to the patient.

- 4.13 To discuss the risks and benefits of special techniques: total-body Irradiation (TBI), intra-operative radiotherapy (IORT) and total-skin electron irradiation (TSEI).
- (5) Optimal and safe use of radionuclides in radiotherapy
- 5.1 To discuss the types of sources used in radiotherapy and their construction, with regard to their efficacy in irradiating target volumes.
 - 5.2 To relate the specification of source strength to the radiation dose delivered to patients.
 - 5.3 To discuss the hazards of specific sources.
 - 5.4 To discuss the principles of clinical use and the associated radiation hazards.
 - 5.5 To discuss the control and testing of sealed sources in relation to the radiation hazard.
 - 5.6 To discuss afterloading including benefits and hazards.
 - 5.7 To discuss the use of unsealed radionuclides for radiotherapy and radiation protection requirements.
- (6) Radiation hazards in radiotherapy facilities
- 6.1 To discuss current national legislation.
 - 6.2 To discuss the design of treatment rooms, including primary and secondary barriers and the effects of leakage and scatter radiation.
 - 6.3 To discuss the design of sealed source storage and dispensing facilities.
 - 6.4 To discuss the measurement of radiation around treatment rooms.

6. Training modules on radiation safety

These modules, recommended for medical applications of ionising radiation, were agreed in September 1999 at the International Conference on “Radiation protection: What are the future training needs?” organised by the “Institut National des Sciences et Techniques Nucléaires” in Saclay (France). For Medical Physicists, all the modules are recommended. For medical doctors and paramedical personnel, all the modules are recommended apart from 15, 16 and 20.

- 1.1 Basic physics, mathematics and biology for radiation protection.
- 1.2 Radiation sources of exposure.
- 1.3 Interaction of radiation with matter.
- 1.4 Dosimetric quantities and units.
- 1.5 Theory of radiation detection and measurement.
- 1.6 Dosimetric calculations and measurements.
- 1.7 Biological effects of ionising radiation.
- 1.8 External dose assessment.
- 1.9 Internal dose assessment.
- 1.10 The role of International Organisations in radiation protection (not essential).
- 1.11 Conceptual framework of radiation protection.
- 1.12 Occupational radiation protection.
- 1.13 Waste safety.
- 1.14 Physical protection and security of sources.

- 1.15 Transport of radioactive material.
- 1.16 Public exposure control.
- 1.17 Intervention for protection of the public in chronic and acute exposure situations.
- 1.18 Medical exposures.
- 1.19 Regulatory control.
- 1.20 Communications on nuclear radiation transport and waste safety.
- 1.21 Emergency preparedness and response. Accident analysis.
- 1.22 Safe use of radiation sources in relation to specific practices.

7. Council Directive 97/43/EURATOM of 30 June 1997. Extracts of Articles concerning training aspects

Article 7 (covering training) of Council Directive 97/43/EURATOM of 30 June 1997 on health protection of individuals against the dangers of ionising radiation in relation to medical exposure. Official Journal of the European Communities, L 180:22-27; 9.7.97, contains some aspects that might require some clarification and orientation for Member States.

The content of Article 7 is as follows:

1. Member States shall ensure that PRACTITIONERS and INDIVIDUALS MENTIONED in Articles 5(3) and 6(3) have adequate theoretical and practical training for the purpose of radiological practices, as well as relevant competence in radiation protection.

For this purpose Member States shall ensure that appropriate curricula are established and shall recognise the corresponding diplomas, certificates or formal qualifications.

[Practitioner: a medical doctor, dentist or other health professional, who is entitled to take clinical responsibility for an individual medical exposure in accordance with national requirements.

5(3) The practical aspects for the procedure or part of it may be delegated by the holder of the radiological installation or the practitioner, as appropriate, to one or more INDIVIDUALS ENTITLED TO ACT in this respect in a recognised field of specialisation.

6(3) In radiotherapeutic practices, a MEDICAL PHYSICS EXPERT shall be closely involved. In standardised therapeutic nuclear medicine practices and in diagnostic nuclear medicine practices, a medical physics expert shall be available. For other radiological practices, a medical physics expert shall be involved, as appropriate, for consultation on optimisation including patient dosimetry and quality assurance including quality control, and also to give advice on matters relating to radiation protection concerning medical exposure, as required.]

2. Individuals undergoing relevant training programmes may participate in practical aspects for the procedures mentioned in Article 5(3).

3. Member States shall ensure that continuing education and training after qualification is provided and, in the special case of the clinical use of new techniques, the organisation of training related to these techniques and the relevant radiation protection requirements.
4. Member States shall encourage the introduction of a course on radiation protection in the basic curriculum of medical and dental schools.

Article 9 (Special Practices) also contains some references to training questions:

Article 9(2): Member States shall ensure that practitioners and those individuals referred to in Article 5(3) performing the exposure referred to in the first paragraph [exposure of children, exposure as part of a health screening programme, and exposure involving high doses to patient, such as interventional radiology, computed tomography or radiotherapy], obtain appropriate training on these radiological practices as required by Article 7(1) and 7(2).

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TABLE 1									
TRAINING AREA	DR MD	RT MD	NM MD	CD MD	DT	MD	RD	NU	ME
Atomic structure, production and interaction of radiation	m	h	h	l	l	l	m	l	m
Nuclear structure and radioactivity	m	h	h	l	--	--	m	l	m
Radiological quantities and units	m	h	h	m	l	l	m	l	m
Physical characteristics of the X-ray or therapy machines	m	h	l	m	l	m	m	l	h
Fundamentals of radiation detection	l	m	h	l	l	l	m	l	h
Fundamentals of radiobiology. Biological effects of radiation.	m	h	h	m	l	m	m	l	l
Radiation protection. General principles	h	h	h	h	m	m	h	l	m
Operational radiological protection	h	h	h	h	m	m	h	m	m
Particular patient RP aspects	h	h	h	h	m	h	h	m	m
Particular staff RP aspects	h	h	h	h	m	h	h	m	m
Quality control and quality assurance	m	h	h	m	l	l	m	l	h
National and European regulations and standards	m	m	m	m	m	m	m	l	h
Suggested number of training hours	30-50	40-60	30-50	20-30	10-15	15-20	40-100	10-15	40-60

DR/MD = Diagnostic Radiology Specialists (Medical Doctors)

RT/MD = Radiotherapy Specialists (Medical Doctors)

NM/MD = Nuclear Medicine Specialists (Medical Doctors)

One additional training area on Radiopharmaceuticals: Handling, quality control and detection should also be considered (h level).

CD/MD = Interventional Cardiology Specialists (Medical Doctors)

DT = Dentists

MD = Other Medical Doctors using X-ray systems

RD = Radiographers

The term "radiographer" is understood to include radiographer, medical radiological technologist, radiation therapy technologist or nuclear medicine technologist.

Some specific training depending of the kind of job will be needed.

The EANM suggest 30-50 h for nuclear medicine technologists and one additional training area on Radiopharmaceuticals: Handling, quality control and detection (h level).

NU = Nurses

Some specific training will be needed in Nuclear Medicine and Radiotherapy

ME = Maintenance Engineers

Other groups of practitioners not included in the table should adapt their training in a similar framework.

Level of knowledge:

l = Low level of knowledge

m = Medium level of knowledge

h = High level of knowledge

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ABSTRACT

The medical exposure directive (97/43/Euratom) stipulates that Member States shall ensure that practitioners and the rest of the staff involved in a radiological procedure have adequate theoretical and practical training for the purpose of radiological practices, as well as relevant competence in radiation protection. It requires Member States to establish the appropriate curricula and the recognition of corresponding diplomas, certificates or formal qualifications, and to encourage the introduction of a radiation protection course in the basic curriculum of medical and dental schools.

These guidelines contain some specific recommendations on education and training for the different groups of professionals involved in medical exposures, the aim being to provide some clarification and orientation for the application of the Directive. The annexes present topics to be included in some of the training activities.