

The syllabus on fundamental radiation protection courses for radiologists in Turkey, (2011-2013)

C. T. Zeyrek^a, H. Akbıyık^a

^aAnkara Nuclear Research and Training Center

Turkish Atomic Energy Authority

TR-06100, Beşevler, Ankara, Turkey

E-mail address of main author: zeyrek@taek.gov.tr

Abstract.

We aimed to describe the Turkish experience in radiation protection (RP) and communicate our experience in the organization of RP training courses for radiologists. The courses provided theoretical and practical knowledge on RP on the basis of scientific and technical recommendations from The International Commission on Radiological Protection (ICRP), The Council Directive 97/43/EURATOM and the International Atomic Energy Agency (IAEA). Courses were organized by the Ankara Nuclear Research and Training Center (ANAEM), a branch of Turkish Atomic Energy Agency aimed at providing specialized RP education for radiologists, medical doctors, technicians, physicians, and radiation workers. The courses were presented as five-day seminars by a group of instructors composed of a physicist, radiation biologists, RP experts, and medical physicists. The implemented RP training programs were effective and efficient according to the overall assessments obtained by the ANAEM. Similar training programs can be organized for cardiologists and other medical practitioners conducting interventional procedures by institutions and organizations in accordance with the Turkish RP regulations. To this end, we suggest that RP training courses should be accredited and sustained at the national level.

1. Introduction

Training in radiological protection (RP) is widely recognized as one of the basic components of radiological optimization programs for reducing medical exposures. Occupational and patient radiological risks during procedures used in interventional radiology can be quite high. Consequently, continuous education programs regarding RP are of paramount importance to ensure that the radiation doses to which patients and staff exposed are minimized as much as possible.

Radiology utilizes minimally invasive image-guided procedures to diagnose and treat some diseases in the organ system. The focus of radiology is to diagnose and treat patients while using the least invasive techniques currently available to minimize patient risk and obtain favorable health outcomes. Fluoroscopy is extensively used to conduct and document interventional radiology procedures. Professionals and patients in this medical field can encounter significant radiological risks. Radiological protection, therefore, is an important issue in the design of X-ray rooms, the selection and purchase of equipment, and in routine practice and training.

The International Commission on Radiological Protection (ICRP) published general recommendations for RP and radiation safety for interventional radiology [1]. The ICRP recommends that interventional radiologists receive training in RP for their patients, their staff, and themselves and that this training should include guidance on how to properly use personal protective equipment and monitor exposure.

The International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) have also made relevant efforts to promote radiation safety in radiology. Their main publications on this topic include recommendations for areas of training in both medical aspects and RP [2-5]. The WHO published one of the first and most complete publications with detailed orientations on the different levels of training requirements (basic, intermediate, advanced) for different topics and personnel involved in radiology procedures [2]. The IAEA also published the Standard Syllabus Training Course Series, which serves as a guide for standardized curricula with postgraduate educational courses in radiation protection and the safe use of radiation sources [5].

European Council Directive 97/43/EURATOM [6] established in Article 7 that “Member States shall ensure that practitioners and those individuals mentioned in Articles 5 [3] and 6 [3] [medical physics experts and other staff members involved in radiological practices] have adequate theoretical and practical training for the purpose of radiological practices, as well as relevant competence in RP. For this purpose, Member States shall ensure that appropriate curricula are established and shall recognize the corresponding diplomas, certificates or formal qualifications.” In addition, according to Article 9.2 in the Council Directive, appropriate training should be given to practitioners and other staff members performing radiological practices for the medical exposure involving high doses to the patient such as interventional radiology, computed tomography or radiotherapy. The European Commission’s published guideline commends education and training in radiation protection for medical exposures and includes specific recommendations for interventional radiology [7]. Additionally, the European Guideline emphasizes 20 to 30 hours of training as well as the accreditation process. The European Association of Radiology (EAR) further defines the “core of knowledge for general radiology” syllabus in its recommendations [8].

In Turkey, national legislation requires specific training in RP (Official Journal of Turkish Government, 2000), and the ANAEM affiliated with the Turkish Atomic Energy Agency (TAEA) decided to organize and coordinate a pilot course to implement training for RP in the country. The duties and responsibilities of the ANAEM include national education, training, and research on topics of RP, such as radiation safety, nuclear power, nuclear safety, and the application of nuclear energy and radiation.

In this report, we present the Turkish experience in RP training for radiology. We describe how RP training for interventional radiologists is organized and identify the primary components of a syllabus for Turkish RP courses. The general learning objectives, main content, and duration of RP courses are summarized.

2. Methods

2.1. Legislation and regulatory requirements in Turkey

The TAEA regulates and supervises all topics in RP. The TAEA was reformed by the new Act (No: 2690, year 1982); with its main objective to set policy for nuclear energy, nuclear regulation, licensing, inspection, as well as for nuclear research, training and development. The TAEA is the established authority for radiation protection and nuclear safety [10]. The Department of Radiation Health and Safety (RSGD) is affiliated with the TAEA and has duties and responsibilities in implementing tasks [established by the Turkish Atomic Energy Authority Law (No: 2690, Article: 8-b)] concerning the services related to the licensing, regulation, transportation and storage of

radioactive materials, inspection of instruments and systems connected with radiation, and other related duties [9]. The protection and safety objectives of the TAEA contained in the National Regulations of Radiation Security are consistent with IAEA-The Basic Safety Standards (BSS) and ICRP recommendations [1,3].

In accordance with Turkish Legislation, every public and private foundation/establishment that uses exposure devices or sources for all practices and activities must be registered and licensed by the TAEA-RSGD [9]. According to the National Regulations of Radiation Security [9], training and experience are key elements in the first phase of issuing a license to any public or private foundation/establishment that uses exposure devices/sources in their activities, and employers, registrants, licensees, and workers should have suitable appropriate and periodic education and training in RP and radiation safety.

The National Regulation of Radiation Safety, in Article 4-i, (No: 23999) [9] defines an RP officer and his/her required qualifications. An RP officer must be a qualified person trained in the basic safety standards for RP and who implements these standards according to the characteristic requirements of his/her job. This individual must also have a proven track of record of accomplishment in this field that has been approved by the TAEA.

To apply for a license, one must first be a qualified RP officer who has successfully completed the appropriate training courses in his/her field. This requirement is spelled out in Regulation Article 73 of the National Regulations of Radiation Security, which states that any facility dealing with radiation, including radiation sources, shall have an RP officer certified by the TAEA.

Recently, the TAEA issued “The Procedures and Principles for Implementation of Trainings in Radiation Protection” on May 3, 2013 [11]. According to this new regulation, public and private enterprises can also conduct radiation protection training/courses provided that they first be approved and licensed by the TAEA. Articles pertaining to training objectives, training topics, selection criteria for lecturers, and technical infrastructures were also defined in this regulation [11].

2.2. Ankara Nuclear Research and Training Center (ANAEM)

Education and training in RP for radiology must meet the needs of professionals at the graduate level or the equivalent. Initial training should establish a basis in RP and the safe uses of radiation sources and equipment. The training courses are designed to provide the necessary basic tools for those who plan to become RP trainers in Turkey. In course planning, recommendations from The ICRP, The Council Directive 97/43/EURATOM and standards on radiation protection and their implementations [2,6] are taken into account so that both theoretical and practical sessions in scientific and technical bases are allocated. Council Directive 97/43/EURATOM on medical exposures highlighted these recommendations in Europe. This directive considers interventional radiology (Article 9) to be a special practice that involves high doses to the patient.

Interventional practices imply additional risks, due to more complex procedures and the requirement for more operator time near the patient during the fluoroscopic screening, and also carry the risk of deterministic effects on the patient [8]. For this reason, RP training of interventional radiologists is considered important to help minimize these risks.

The planning and implementing of these courses requires oversight by a group formed by experts working in the field, called the Ankara Nuclear Research and Training Center (ANAEM). The ANAEM was established on 18.08.2010 upon the Council of Ministers’ Decision and published on 30.09.2009 in the Official Gazette with the legislation number [12]. The ANAEM conducts various radiation protection and pilot apprenticeship training courses focusing on the specialized training of radiologists, medical doctors, technicians, physicians and radiation workers and rates the outcomes of these activities by known teaching evaluation methods.

These specialized courses are tailored to the needs of the public and private sectors and are thus called “sector-specific courses.” RP training for interventional radiologists represents an example of one of these courses that is periodically held by the ANAEM during the year. The course programs are announced before the beginning of the year on the TAEA website. The training courses, held by the ANAEM itself or in collaboration with another appropriate training center affiliated with TAEA, are conducted by qualified instructors working in the field. These instructors are selected from the TAEA’s own instructor repository or from universities that have been working in parallel with the targeted activities.

The main duty of the ANAEM is to meet the qualified manpower needs for all practices and activities involving the use of ionizing radiation in Turkey. The divisions and duties of the ANAEM are as follows:

- *The Training Administration Division* is responsible for establishing efficient, productive, standardized and systematic national and international trainings and to ensure that these trainings are conducted by qualified trainers. In addition, this division develops teaching materials and methods, maintaining and updating them according to current needs. This division cooperates with other national institutions as needed.
- *The Training Application Division* organizes trainings on radiation protection, radiation safety, nuclear power, nuclear safety, nuclear assurance, nuclear technology, and related subjects. The division is responsible for implementing the Annual National Education Program approved by the TAEA administration.
- *The Public Information Division* arranges seminars, workshops, and formal meetings, preparing and updating written and visual materials, to disseminate effective and transparent public information for people or groups in the range of interest.

2.3. Training objectives and course syllabus in radiation protection for interventional radiologists

The EAR has presented a syllabus for radiation protection on “diagnostic imaging-physical and biological aspects,” prepared by its working group [8]. This syllabus contains 40 hours of theoretical education, supplemented by demonstrations to fulfill the demands. The standard syllabus along with the postgraduate educational course syllabus in radiation protection and the safe use of radiation sources were also provided by the Standard Syllabus Training Course Series of the IAEA [5].

From the point of view of the ANAEM, the syllabus for radiation protection and the safety of radiation sources and RP equipment is to be integrated into the curricula of educational institutions in Turkey to promote consistency and create a standardized level of technical content in such courses. The focus of the courses on technical and administrative frameworks is necessary for regulatory and operational controls to protect against ionizing radiation in radiological applications. The course syllabus on radiological protection for radiologists in Turkey has been implemented according to the following content in the final course programme of the ANAEM:

Table 1 summarizes the general learning objectives and durations of the RP courses. Table 2 shows the percentage of total course time devoted to each module in the course syllabus on radiological protection for radiologists implemented by the final course program of the ANAEM.

2.4. Implementation of radiation protection courses for radiologists

The course programs were announced on the TAEA website at the beginning of each year. The courses were presented to the participants as five-day seminars (total 40 hours) by a group of instructors comprising physicists, radiation protection experts, radiation biologists, and medical physicists.

3. Results

To date, over fourteen RP courses for radiologists have been organized by the ANAEM, and 314 participants participated between 2011 and 2013. About 100 participants were interventional radiologists. This activity continued into 2014. The appropriate training material and arrangements were used in both theoretical and applied sessions. Applied sessions primarily took place in a private hospital's radiology and fluoroscopy laboratory and in the medical physics laboratory of an institute that was participating under an agreement with the TAEA. This facility was informed and provided with official letters requesting appropriate time availability in advance prior to the beginning of each course. In the applied sessions, analyses of patient and staff doses for the fluoroscopy and cine acquisition modes were conducted, and differences in image quality and dose values were highlighted.

The participants were monitored with thermoluminescent dosimeters (TLDs) during on-the-job training by the National Dosimetry Service [13,14]. The TLDs were based on the Panasonic model UD-802 dosimeter. The UD-802 model TLD consists of two different phosphor types ($\text{Li}_2\text{B}_4\text{O}_7\text{:Cu}$ and $\text{CaSO}_4\text{:Tm}$), which when using the appropriate holder can measure the dosimetry of photons and beta radiation. The minimum detectable dose level (MDL) was 0.1 mSv per our national dosimetry service. Radiation workers who had effective doses less than 0.1 mSv (MDL) were considered as non-exposed. Therefore, doses falling below the MDL were recorded as zero; the effective dose exposure for all participants was less than 1 mSv during the course periods.

During each course, revised training/course notes were prepared and disseminated to the course participants for future reference. At end of the each training course, participants completed a test. Based on this test score, one of two different certificates was issued. If the examination score was 70 or above out of 100, a "Certificate of Achievement" was issued; for lower scores, a "Certificate of Attendance" was given. 312 participants completed the examination with a high score and received a "Certificate of Achievement" from the TAEA between 2011 and 2013.

Course evaluation questionnaires were completed by the participants at the end of each course. Table 3 contains participants' ratings of the training courses, evaluating their instructors within their own assigned syllabus content on a five-point scale. The questionnaires primarily documented the best- and worst-rated aspects of the training courses for the years 2011 and 2013 (Table 4). Participant feedback on the quality and effectiveness of the training was taken into account in the improvement of the next set of courses. At the same time, feedback from the inspectors of the RSGD affiliated with the TAEA was also incorporated.

4. Discussion

In this report we briefly described the current regulations and requirements for RP in Turkey and shared our experience in the organization of RP training courses for radiologists.

The current RP training programs appear quite beneficial and useful in fulfilling the intended purpose of promoting the protection of patients and staff from the harmful effects of radiation. Educational programs in radiation physics, radiobiology, and RP are currently well defined. The guidelines for establishing the content in educational courses have been designated through collaboration among organizations such as the EAR and the European Federation of Organizations of Medical Physics. Combined training programs as well as on-the-job training programs were found to be effective and efficient. Overall, our findings suggest that RP education and training for diagnostic and interventional radiology should be implemented at all levels of education, including continuous training for practitioners with professional experience. This training is usually welcomed as long as it is seen as fostering better long-term implementation of RP rules.

5. Conclusion

In conclusion, in Turkey, the relevant authorities have been meeting the radiological training needs for RP. Similar training courses for cardiologists and other medical practitioners conducting interventional procedures can also be organized by institutions and organizations in accordance with the related Turkish regulations. To that end, RP training programs should be accredited and sustained at the national level. This process should be undertaken by the regulatory authority with the help of the ANAEM. Indeed, the TAEA has already begun this process, which is expected to conclude in a year. Therefore, it is hoped that other scientific or professional societies and academic institutions (universities), those that have similar experiences in their field of activity, can organize and implement RP education and training courses providing that they sufficiently meet the criteria determined by regulatory authorities.

Acknowledgements

The authors would like to express their gratitude to the training instructors of the TAEA and the personnel of the ANAEM for their contributions to course delivery.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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Table 1. Overview of the ANAEM syllabus for radiological protection courses

Module	Objective	Main content	Duration (hours)
Fundamental concept of ionizing radiation	To become familiar with the basic knowledge of ionizing radiation.	Atomic structure; radiation sources; radiation dose; external and internal exposure; X-ray production.	4
Units and conversions	To understand measurement units and dosimetric quantities and to perform related calculations.	Dosimetric quantities; RP quantities; application of dosimetric calculations and conversions.	3
Radiation measurement and detection	To be familiar with operating principles and characteristics and to be able to choose the appropriate detectors.	Interaction of X-rays with matter; different types of radiation detectors; practical exercise for measurement.	2
Biological effects of radiation	To become familiar with the mechanisms of different types of biological effects following exposure to X-rays; radiological risks.	Effects of radiation on cells; effects of whole-body irradiation; effects of partial-body (skin, thyroid, eye lens; gonads, etc.) irradiation; stochastic effects; radiation detriment.	3
Principles of radiation protection	To become aware of the ICRP's conceptual framework and international recommendations in RP; to become acquainted with the role played by international organizations; to discuss the optimization of radiology procedures.	Recommendations of the ICRP; optimization of procedures; reference levels; role of international organizations in RP.	2
Personal monitoring, dose limits, typical patient and staff dose levels	To be able to use monitoring programs (whole-body, extremity and skin dosimetry); to be able to apply RP principles to radiology; to understand the concepts used for calculating doses to patients.	Monitoring programs; importance of the suitable location of personal dosimeters; entry dose and dose rate; influence of equipment positioning on occupational doses; effects of using different fluoroscopy modes and personal protection.	3
Radiation shielding for radiology	To become familiar with the shielding for radiology.	General and specialized radiology; safety related to equipment; shielding and calculation of shielding.	2
National regulatory agency	To become acquainted with the elements of the	Scope of National Regulation of Radiation Safety (9);	1

for radiation security	regulatory infrastructure for RP and safety.	Safety requirements and guides; System of notification; registration; licensing and control of radiation sources; training requirements.	
X-ray systems and imaging modalities for IR	To be able to safely operate IR equipment (X-ray and imaging systems, etc.)	X-ray systems; parameters of irradiation; the implications of generated power and heat loading of X-ray tubes; the effect of high additional filtration on conventional X-ray beams; usual focus sizes; operation of continuous and pulsed modes and their benefits in terms of image quality; the benefits of the grid-controlled X-ray tube when using pulsed beams; mapping; temporal integration; new imaging modalities; digital sensors, etc.; practical exercises in the laboratory (X-ray rooms).	5
Dose reduction techniques for radiologists	To become familiar with the operating principles and characteristics for reducing occupational doses.	The most important factors that influence staff doses in IR; relationship of X-ray beam filtration and kV setting to occupational dose; effects of using different fluoroscopy modes on occupational doses; influence of C-arm positioning; influence of radiation field size and the importance of the collimation; effects of personal protection equipment (e.g., leaded aprons, gloves, eyeglasses, thyroid protectors, etc.); impact of distance between the staff and patient; analyses of beam direction (scattering angles, incident beam); the importance of equipment ergonomics in staff protection.	3
Dose reduction techniques for patients	To become familiar with operating principles and characteristics for the reduction of patient doses.	Analysis of correlation between the number of images taken in a procedure and the dose received by patients; effects of focus-to-skin distance and placement of the image intensifier; the effect of using an anti-scatter grid on patient dose; typical values of patient entry doses in high- and low-dose fluoroscopy modes; modifying the image rate in cine or digital acquisition for dose reduction; the importance of using different C-arm protections in some high-dose procedures; the effect of using different magnifications on patient dose; the cost-benefit relationship between concentration and type of radiological procedure and image quality.	2
QA programs	To become familiar with QA programs and their	QA procedure; periodical control of irradiation and image parameters; importance in QA programs of periodical control of	2

	importance in dose reduction.	patient dose and its comparison with reference dose levels.	
On-the-job-training for dose reduction	To be able to use knowledge obtained in the RP course in practice.	Application of dose reduction techniques for interventional radiologists and patients in the laboratories (X-ray rooms).	8
ICRP, International Commission on Radiological Protection; RP, radiation protection; QA, quality assurance			

Table 2. The percentage of total course time devoted to each module in the course syllabus

Modules	Percentage of total course time
Fundamental concept of ionizing radiation	9.3%
Units and conversions	7.0%
Biological effects of radiation	4.7%
Radiation measurement and detection	7.0%
Principles of radiation protection	4.7%
Personal monitoring, dose limits, typical patient and staff dose levels	7.0%
Radiation shielding for radiology	4.7%
National regulatory for radiation security	2.3%
X-ray systems and imaging modalities	12.0%
Dose reduction techniques for interventional radiologists	12.0%
Dose reduction techniques for patients	7.0%
Quality assurance programs	4.7%
On-the job-training for dose reduction	19.0%
Total	100%

Table 3. Participants' ratings of radiation protection courses/instructors

Modules	Participants' rating
Fundamental concept of ionizing radiation	4.5
Units and conversions	4.4
Biological effects of radiation	4.0
Radiation measurement and detection	4.2
Principles of radiation protection	4.2
Personal monitoring, dose limits, typical patient and staff dose levels	4.1
Radiation shielding for radiology	4.0
National regulatory for radiation security	4.2
X-ray systems and imaging modalities	4.1
Dose reduction techniques for radiologists	4.3
Dose reduction techniques for patients	4.3
Quality assurance programs	4.2
On-the-job training for dose reduction	4.0

Ratings were performed on a five-point scale

Table 4. Participants' assessment of the radiation protection training courses for the years 2011–2013

Participants' assessment		
Class location	Unsuitable	3%
	Suitable	97%
On-the job-training	Insufficient	4%
	Sufficient	21%
	Satisfactory	75%
Scope of the educational content	Disagree	2%
	Partly agree	19%
	Fully agree	79%
Provided handouts	Insufficient	24%
	Sufficient	76%
Course duration	Long	10%
	Suitable	90%