RADIATION PROTECTION IN MEDICINE

Diagnostic, interventional and therapeutic uses of ionizing radiation are beneficial for hundreds of millions of people each year by improving health care and saving lives. In March 2001, the first International Conference on the Radiological Protection of Patients was held in Malaga, Spain, which led to an international action plan for the radiation protection of patients. Ten years after establishing the international action plan, the "International Conference on Radiation Protection in Medicine: Setting the Scene for the Next Decade" was held in Bonn, Germany, in December 2012. The main outcome of this conference was the so called "Bonn Call for Action" that identifies ten priority actions to enhance radiation protection in medicine for the next decade. The IAEA and WHO are currently working in close cooperation to foster and support the implementation of these ten priority actions in Member States, but their implementation requires collaboration of national governments, international agencies, researchers, educators, institutions and professional associations.

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PROTECCIÓN RADIOLÓGICA EN MEDICINA

La utilización diagnóstica, intervencionista y terapéutica de la radiación ionizante beneficia a cientos de millones de personas cada año, mejorando su atención sanitaria y salvando vidas. En marzo de 2001, tuvo lugar en Málaga, España, la primera Conferencia Internacional sobre la protección radiológica de los pacientes que dio lugar a un plan de acción internacional. En diciembre de 2012, tuvo lugar en Bonn, Alemania la segunda *Conferencia Internacional sobre Protección Radiológica en Medicina: preparando la escena para la próxima década*. El principal resultado de esta conferencia fue la *Llamada a la acción de Bonn* en la que se identifican diez acciones prioritarias para mejorar la protección radiológica en medicina para la próxima década. El OIEA y la OMS trabajan en estrecha colaboración para fomentar y apoyar la aplicación de estas medidas prioritarias en los Estados miembros, pero para su aplicación se necesita la cooperación de instituciones gubernamentales, organismos internacionales, investigadores, educadores, y asociaciones profesionales.

BACKGROUND

There is no doubt that diagnostic, interventional and therapeutic uses of ionizing radiation are beneficial for hundreds of million of people each year by improving health care and saving lives. Among all the many uses of radiation, medical exposure is, by far, the most predominant. Radiation protection of patients is very special because too little or too much exposure is problematic and the risk from procedures ranges from negligible to potentially fatal. No dose limits are applicable to patients, who are deliberately exposed to get a benefit from the radiation itself (e.g. to obtain an image for diagnosis, to guide an intervention, to treat a disease), sometimes purposely exposing sensitive subgroups, such as children, or purposely delivering radiation doses that may cause deterministic effects, such as in the case of radiotherapy. It is estimated that every day around the world, ionizing radiation is being used for the imaging of patients in more than ten million diagnostic radiology procedures and one hundred thousand diagnostic nuclear medicine procedures, while twenty thousand radiotherapy courses are started along with many therapeutic nuclear medicine procedures (Holmberg, 2011; UNSCEAR, 2008).

In the 2008 report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) , the total annual collective effective dose relative to medical exposure (excluding radiotherapy) stood at 4.2 million man Sv, an increase of 1.7 million man Sv (65 %) over the previous 2000 report (UNSCEAR, 2000; 2008). Medical exposures account for 98 % of the dose contribution from all artificial sources and represent 20 % of the total population exposure (Vañó, 2011). In countries with good access to radiation imaging and therapy, this proportion is much higher. For example, the radiation dose to the population of the United States of America from medical radiation is now equal to that of background radiation, and increased more than seven times in 25 years.

The global figure for the effective dose per capita from medical exposure was estimated by UNSCEAR to have increased from 0.3 mSv (UNSCEAR, 1993) to 0.4 mSv (UNSCEAR,

2000), reaching a current value of 0.64 mSv (UNSCEAR, 2008). In the United States of America the figure in 2006 amounts to 3.0 mSv (NCRP, 2009), indicating clearly the trend of rising radiation burden from medical exposure. In themselves, these figures are not a problem, but can be seen as an indication that access to and use of radiation in medicine is increasing for the global population.

The increase in medical radiation exposure of the population is primarily the result of the growth in the use of medical imaging. Modern medicine demands rapid diagnosis and treatment and radiation imaging is an essential component of patient management. Many patients have multiple investigations using ionizing radiation, particularly computed tomography (CT). There has been an inexorable rise in the range and numbers of minimally invasive interventional techniques being performed using fluoroscopy and these techniques have offered enormous benefits to many patients who otherwise may not be candidates for more invasive surgery (Cousins, 2012).

Unnecessary exposure of patient can arise from medical procedures that are not justified for a specific objective, and from procedures that are not optimized for the situation in which they are being used. Unintended and accidental exposure can arise from unsafe design or inappropriate use of technology (Vañó, 2011; Colgan, Holmberg et al., 2014).

HISTORY AND MAJOR MILESTONES

The second International Congress of Radiology (ICR) was held in Stockholm in 1928 at which what is now the International Commission on Radiological Protection (ICRP) was established under the name of the 'International X-ray and Radium Protection Committee' and its first report focused on the occupational protection in X ray diagnostic and radiation therapy, The current ICRP series of publication startet in 1959 with Publication 1 (ICRP, 1959), in which medical exposure was recognized under the categories of exposure, but the report stated that "no recommendations are given with regard to the dose to the individual from medical exposure". The protection of patients, remained excluded from the scope until Publication 9 (ICRP, 1966), which, citing UNSCEAR reports (UNSCEAR, 1962; 1964), recognized that measures can be taken to reduce medical exposure without loss of medically important information. Soon after this statement, the first task group explicitly charged with patient protection in x-ray diagnosis was established, whose work resulted in Publication 16 (ICRP, 1970) with the title Protection of the Patient in X-ray Diagnosis.

In the 1970s, the Nationwide Evaluation of X-Ray Trends (NEXT) surveys began in the United States and in the 1980s the National Radiation Protection Board (now Public Health England) surveys in the United Kingdom measured entrance surface exposure. The results of these and similar surveys were the basis for recommendations for radiographic technique and patient dose, first developed in the United States, then in the United Kingdom and, subsequently, Europe. Surveys soon showed large differences in patient exposure among different hospitals for the same type of examinations, thus suggesting a large potential for reduction of population exposure. In addition, collections of accidental exposure in radiotherapy as well as radiation injuries from interventional procedures were made available in the 1990s. In the 1990s the Interntational Basic Safety Standards (BSS, 1996) as well as the European Safety Standards Directive established requirements for the protection in medical exposure.

In March 2001, an International Conference on the Radiological Protection of Patients was held in Malaga, Spain. A major outcome of this conference was a request to the IAEA to formulate an action plan for future work relating to the radiation protection of patients. The overall objective of this action plan was to make progress in the radiation protection of patients as a whole, noting that the involvement of international organizations and professional bodies is crucial to performing the actions and achieving the goals outlined in it. The International Action Plan on the Radiological Protection of Patients (IAP RPoP) was prepared and approved by the IAEA governing bodies in 2002. The ultimate purpose was to ensure that radiological protection is an integral part of medical practice by recognizing the benefits of medical uses of radiation and promoting radiological protection without limiting the medical benefits.

Ten years after establishing the international action plan, the "International Conference on Radiation Protection in Medicine: Setting the Scene for the Next Decade" was held in Bonn, Germany, in December 2012, organized by the International Atomic Energy Agency (IAEA) and co-sponsored by the World Heath Organization (WHO). The main outcome of this conference was the so called "Bonn Call for Action" that identifies ten priority actions to enhance radiation protection in medicine.

DIAGNOSTIC RADIOLOGY

The 2008 UNSCEAR report shows estimates that the total number of diagnostic medical examinations (both medical and dental) have risen from 2.4 billion in the survey described in the previous UNSCEAR report (covering the period 1991–1996), to 3.6 billion—an increase of 50 % (UNSCEAR 2000; 2008). As part of that trend, computed tomography scanning, has given impetus to the annual number of procedures performed in many countries and, by extension, to collective doses. For several countries and for the first time in history, this has resulted in a situation in which the annual collective and 'per capita' doses of ionising radiation due to diagnostic radiology have exceeded the doses from the previous largest radiation source (i.e. natural background radiation) (Vañó, 2011).

NUCLEAR MEDICINE

In diagnostic nuclear medicine, an estimated 32.7 million examinations are presently performed annually worldwide, which represents an increase of 0.2 million examinations or 1 % per year since the 1991–1996 survey. Over that same period, the collective effective dose due to nuclear medicine examinations has risen from 150 000 to 202 000 man Sv, representing an increase of 52 000 man Sv, i.e. about 35 %. Nuclear medicine represents roughly 6 % of the collective dose of the diagnostic use of radiation (UNSCEAR 2000 and 2008, Vañó 2011).

RADIATION THERAPY

For radiation therapy, developed countries account for about 70 % of all radiotherapy treatments. An estimated 5.1 million courses of radiotherapy treatment were administered annually between 1997 and 2007, against an esti-

mated 4.3 million in 1988. About 4.7 million of those treatments involved teletherapy and 0.4 million brachytherapy.

Radiation therapy is the only practice in which human beings are intentionally exposed to very high-radiation doses (20–80 Gy). Since the patient is directly in the beam or in contact with radioactive sources, any human mistake or equipment fault affecting the radiation beam may have devastating and even fatal consequences. Not only overdosage but also underdosage may be fatal if not discovered soon.

INCIDENTS AND ACCIDENTS

In radiation medicine, accidents generally involving errors in the delivery of radiotherapy are often detected only after many patients have been overexposed. UNSCEAR, reported the review of 29 reported accidents –involving 45 deaths and 613 injuries– since 1967. All the deaths and injuries related to the medical use of radiation have very likely not been reported. However, what can be deduced is thatradiation accidents involving medical uses have accounted for more deaths and early acute health effects than any other type of radiation accident, including accidents at nuclear facilities. The current figures are likely to be underestimates, and possibly significantly so, because of underreporting.

JUSTIFICATION AND OPTIMIZATION

A radiological procedure provides more benefits than risks when it is appropriately prescribed and properly performed (i.e. justified and optimized). Justification of procedures and optimization of protection are the two pillars of radiological protection in health care. These principles may be taken as an extension of the well-established medical principle of "first do no harm" and are implicit in the notion of good medical practice. However, some health professionals are not familiar with them, and have a low awareness of radiological protection aspects of justification (Perez, 2015).

Overutilization of 20–30% of imaging examinations is reported in the literatura (Cascade, 1998). Hendee et al. noted that 20–50% of CT examinations are potentially not justified (Hendee, 2010). In the "Proceedings" of the workshop on Justification of Medical Exposure in Diagnostic Imaging organized by the EC and the IAEA, Malone indicated that the use of referral or appropriateness guidelines would lead to a rapid dose reduction of 20% with a potential 40% reduction (Malone 2011). To achieve this, it is likely that local and regional guidelines will have to be developed. Much progress has been made over the years in addressing the optimization of medical exposures and increasing safety in medical exposure. There has been less progress made in addressing the justification of medical exposure over the years (Holmberg, 2015).

IAEA is promoting the adoption in Member States of mechanisms to achieve patient exposure tracking, in support to optimization and justification.

A series of IAEA technical meetings aim to develop further practical steps to achieve meaningful, international collaboration in the creation, deployment, and application of Clinical Imaging Guidelines (CIG). A series of papers that followed define such an approach to improve the use of imaging and, by extension, patient health worldwide (Remedios, 2015; Malone, 2015; Babcock, 2015; Bettmann, 2015).

Advocacy for guidelines should include the expectations that they will facilitate: (1) better health care delivery; (2) lower cost of that delivery; with (3) reduced radiation dose and associated health risks. Radiation protection issues should not be isolated; rather, they should be integrated with the overall health care picture. The information about radiation doses and risks to be provided with guidelines should include the uncertainty involved and advice on application of the precautionary principle with patients.

Optimization in radiation protection means keeping doses "as low as reasonably achievable" (ALARA). For medical imaging, ALARA means delivering the lowest possible dose necessary to acquire images that are adequate for making a diagnosis or guiding an intervention. Modern equipment provides more opportunities for reducing the dose without losing diagnostic information and this is especially important in paediatric imaging. Exposure settings have to be tailored for children. Diagnostic reference levels (DRLs) are useful tools for optimization in medical imaging.

OCCUPATIONAL EXPOSURE IN MEDICINE

Monitoring and reporting of occupational exposures in the medical sector is less comprehensive than in other areas of occupational exposure. About 9.8 million of workers are exposed to artificial sources of radiation worldwide and health workers constitute the largest proportion (75 % of the total). The annual collective dose to workers involved in the medical use of radiation is estimated to be about 3540 man Sv; the average annual effective dose is about 0.5 mSv. The average annual dose to workers involved in medical uses of radiation increased by a factor of 1.7 from 1994 to 2002 (UNSCEAR 2008).

However, workers involved in interventional procedures have relatively high effective doses; and extremity doses can reach the regulatory limits. Without adequate protective measures, staff performing fluoroscopy-guided interventional procedures may also exceed the new dose limit for the lens of the eye of 20mSv/year and this may increase the risk of developing lens opacities. This might also be the case for staff preparing radiopharmaceuticals, working in PET/CT, cyclotrons, and manual brachytherapy.

As the number of interventional procedures has increased substantially, the number of workers involved in the medical use of radiation increased by a factor of seven in the period from 1975 to 2002 and reached an estimated 7.4 million for 2002.

At the 57th session of the UNSCEAR Committee held in Vienna (Austria) in August 2010, the need to improve data collection, analysis and dissemination for occupational workers and patient exposures was highlighted. Difficulties in achieving any improvement may arise from the large variety of different types of professionals handling the data. Increased quality control of the data to avoid mistakes and analysis of the discrepancies between routinely generated data and that published in papers is to be carried out in the near future.

INTERNATIONAL ATOMIC ENERGY AGENCY

The IAEA has the statutory function of establishing international standards of safety and providing for the application of these standards upon request by Member States. The first international 'basic safety standards' were issued in June 1962. Revisions of these standards were published in 1967, 1982, 1996 and 2014 (BSS, 2014). Radiation protection of patients was initially excluded from the standards but in the 1996 a full chapter was devoted to radiation protection in medical exposure. Since then radiation protection in medical exposure is an important part of the standards.

The IAEA addresses radiation protection of patients through the International Action Plan for the Radiation Protection of Patients, updated with the Bonn Call for Action, which was released as a Joint Position Statement between the IAEA and the World Health Organization (WHO) in July 2013. The activities performed to strengthen radiation protection of patients in therapeutic, diagnostic and interventional procedures internationally, include providing standards, guidance and training; facilitating knowledge exchange; giving technical assistance and building awareness.

Within this framework, the IAEA performs a number of activities, such as the development of standards and guidance, and training material, providing for information exchange via a dedicated Web-site on patient protection (rpop.iaea.org), with more than 60,000 page-views (the total number of pages viewed) and more than one million hits per month, an international campaign for the improvement of justification in medical exposure (AAA-awareness, appropiateness and audit of justification process) the long term tracking of radiation history of individual patients (smart card - smart rad track project), the shared learning of safety significant events in radiotherapy (SAFRON) and X-ray guided interventions (SAFRAD), retrospective evaluation of lens injuries and dose (RELID) in interventional cardiology, Currently, an IAEA Safety Guide on Radiation Protection and Safety in Medical Uses of Ionizing Radiation is being developed, in collaboration with WHO, the Pan American Health Organization (PAHO) and International Labour Office (ILO).

WORLD HEALTH ORGANIZATION

The World Health Organization has established a Global Initiative (GI) on Radiation Safety in Health Care Settings to mobilize the health sector towards safer use of radiation in medicine. The ultimate goal of this initiative is to strengthen radiation protection of patients and health workers by enhancing the safety and quality of radiological medical procedures. In order to maximize benefits with the least possible level of risk, the GI aspires to integrate radiation protection into the concepts of good medical practice and health care service quality.

The initiative brings together health authorities, international organizations, professional bodies, scientific societies and academic institutions in concerted action to improve the implementation of radiation safety standards in healthcare settings. It also seeks to complement the IAPRPoP established by the IAEA. The GI is currently focused on supporting the implementation ofthe "Bonn Call for Action".

The GI addresses justification of medical exposures as one of its priorities: an international consultancy on "Referral Guidelines for Appropriate Use of Radiation Imaging" was held in March 2010 as a kick off event for an international collaboration to make globally available evidence-based CIG, facilitate their implementation, monitor their use and evaluate the impact in different clinical settings. Evidence-based CIG support decision-making for patients with specific clinical conditions (signs /symptoms) but, in contrast, consensus about imaging of asymptomatic people for individual health assessment (IHA) has not yet been achieved. WHO is conducting a project on Justification of the Use of CT in Asymptomatic People for IHA, aimed to develop a a framework for justification of such procedures.. Education of referrers is a key issue and WHO advocates for promoting the use of CIGs as education tools for medical students and young doctors. The WHO GI includes a project on radiation risk communication that is currently focused on the development of tools to support risk-benefit dialogue in paediatric imaging. Under the GI WHO is cooperating with global stakeholders to develop guidance for the establishment and maintenance of a radiation safety culture in health care.

Special aspects related to occupational radiation exposures for health care workers are also dealt within the GI, in the context of the global plan of action for worker's health is being implemented by WHO between 2008 and 2017. This plan is coordinating efforts to protect and improve health at the workplaces, promoting joint actions with ILO and other international organizations, employers, trade unions and other stakeholders. This action plan includes the assessment and management of health risks associated to worker's exposure to occupational hazards including ionizing radiation.

Collaboration between UNSCEAR and WHO under the GI includes data collection on patient exposures, particularly in developing countries where this information is still scarce, and joint actions towards shaping a strategic global research agenda on health effects from medical exposures.

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

The ICRP Committee 3 (Radiation Protection in Medicine) has being issuing concise practice-specific documents in which advice is needed by medical professionals. Recent publications include education and training in radiological protection for diagnostic and interventional procedures, radiological protection outside the imaging department in fluoroscopically and radio-isotopically guided procedures, radiological protection in paediatric diagnostic and interventional radiology; dose to patients from radiopharmaceuticals; patient and staff radiation protection in cardiology; radiation protection in ion beam therapy, protection in cone-beam computed tomography and use of ionising radiation in imaging asymptomatic individuals. The most recent global ICRP recommendations are given in (ICRP 2007a and 2007b).

Committee 3 is currently working in the following drafts: occupational

radiological protection in brachytherapy, justification: framework for justification in medical uses of ionizing radiation, radiological protection in therapy with radiopharmaceuticals, occupational protection issues in radiation imaging guided interventions, diagnostic reference levels for diagnostic and interventional imaging, radiological protection in medicine related to individual radiosensitivity to ionizing radiations and radiation and your patient- a guide for medical practitioners (Ortiz, 2015, Vañó 2015).

EUROPEAN COMMISSION

Directive 2013/59/EURATOM on Basic Safety Standards for protection against the dangers arising from exposure to ionising radiation is binding in its Member States and includes a full chapter on medical exposures updating the requirements of the previous Directive. Several research activities funded by the European Commission are concerned with methodologies aimed at reducing patient exposure to radiation whilst maintaining or improving clinical information, as well as at methodologies to better assess and reduce the exposure of medical staff. Improved methodologies will also be developed to assess and reduce doses to peripheral tissues in all radiotherapy treatments, but in particular in more advanced and innovative procedures.

Relevant issues in the European 'Basic Safety Standards' are: procedures on asymptomatic individuals, for early detection of disease but not as part of a health screening programme, will require specific justification; radiation detriment of the medical radiological staff will be considered during justification and optimisation of medical exposure. The use of diagnostic reference levels is required for interventional procedures. Patient dose information is mandatory for interventional and CT procedures. Patient radiation dose will be part of the clinical report on the examinations. A registration and analysis system of events involving or potentially involving accidental or unintended exposures will be mandatory.

OTHER INTERNATIONAL ACTORS

Industry, standardisation organisations as well as radiation protection societies, many medical societies, societies of medical physics and radiographers also dedicate significant efforts to the radiation safety aspects in medicine.

The Nuclear Energy Agency of the OECD (Organization for Economic Co-operation and Development) published in 2007 the EGIS (Expert Group on the Implications of Radiological Protection Science) Report on Emerging Challenges for Radiation Protection (NEA 2007). This report includes a chapter dedicated to radiation protection in medical exposure highlighting that:

- patient doses need to be known by doctors to help in the justification and optimisation process and to give the appropriate information on radiation risks to the patients.
- industry should collaborate with practitioners to make patient dose values available after the procedures.
- multidisciplinary and horizontal collaboration between ME and other areas of activity in RP should be promoted.

In the paediatric area, the role of the 'Alliance for Radiation Safety in Paediatric Imaging—the Image Gently Alliance' needs to be mentioned. The Alliance is a coalition of healthcare organisations dedicated to providing safe, high-quality paediatric imaging nationwide (initially in USA).

The primary objective of the Alliance is to raise awareness in the imaging community that radiation dose needs to be adjusted when imaging children. The website of the Alliance contains brochures with information for parents and paediatric protocols for computed tomography, interventional radiology and nuclear medicine (Image Gently, 2016).

A number of international, regional and national initiatives are being conducted by professional societies and other relevant stakeholders to improve radiation safety in health care (e.g. Eurosafe, AFROSAFE, LatinSafe).

The new international BSS (BSS, 2014) are cosponsored by eight international organizations[1]. The cosponsoring organizations are currently cooperating to support their implementation in Member States. As the new Euratom BSS, the new international BSS also include a robust framework of safety requirements for medical exposures.

HEALTH AND REGULATORY AUTHORITIES

In a number of countries, regulatory and health authorities work together in medical radiation protection and this is highly beneficial for the users. In many other countries, however, there is still a scope for improvement in this collaboration.

Multiple inspections or audits of the radiation safety aspects in medical practice are sometimes perceived as negative by the clinicians. However, the cooperation of the different authorities in these matters generates a more positive perception of any audit.

This cooperation between both regulatory and health authorities will eventually result in a global management of radiation safety aspects hopefully bridging the gap between radiation protection for staff and radiation protection for patients.

SUMMARY OF THE "BONN CALL FOR ACTION"

There is a need for a holistic approach which includes partnership of national governments, civil society, international agencies, researchers, educators, institutions and professional associations aiming at identifying, advocating and implementing solutions to address existing and emerging challenges; and leadership, harmonization and co-ordination of activities and procedures at an international level. The main outcome of the International Conference on Radiation Protection in Medicine: Setting the Scene for the Next Decade" was the so called "Bonn Call for Action" that identifies ten priority actions to enhance radiation protection in medicine for the next decade. The aims of the Bonn Call for Action are to a) strengthen the radiation protection of patients and health workers overall; b) attain the highest benefit with the least possible risk to all patients by the safe and appropriate use of ionizing radiation in medicine; c) aid the full integration of radiation protection into health care systems; d) help improve the benefit/risk-dialogue with patients and the pub-

[1]EC, FAO, IAEA, ILO, OECD/NEA, PAHO UNEP and WHO.

lic; and e) enhance the safety and quality of radiological procedures in medicine.

The priority actions are the following:

1) enhance the implementation of the principle of justification, inluding the 3A's (awareness, appropriateness and audit), developing harmonized appropriateness criteria for the use of radiation imaging, and using electronic decision support means for facilitating their application;
2) enhance the implementation of the principle of optimization, including diagnostic reference levels, quality assurance programmes, and electronic solutions for recording patient exposure;
3) strengthen manufacturer´s role in contributing to the overall safety, by enhancing the radiation protection features in the equipment and software, making these available as default rather than optional, enhancing the provision of training for user of equipment, including radiation protection and safety aspects, conformance to applicable standards, addressing sustainability of equipment in health care settings with limited infrastructure; strengthening cooperation and communication between manufacturers and health professionals
4) strengthen radiation protection education and training of health professionals, both globally as well as specifically for groups of specialists, integrate the training into the curricula, strengthening collaboration among training providers and using the Internet
5) shape and promote a strategic research agenda for radiation protection in medicine, recognizing that an an overwhelming percentage of human exposure to man-made sources is medical; strengthening research on low dose health effects, especially in children and pregnant women; individual radiosensitivity and hypersensitivity; possible identification of biological markers that are specific to ionizing radiation; improving methods of patient dose assessment;
6) increase availability of improved global information on medical exposures and occupational exposures in medicine; fostering cooperation for collecting dose data and trends;
7) improve prevention of medical radiation incidents and accidents by supporting participation in voluntary education safety reporting systems and applying the learning from experience; harmonizing taxonomy and communication means such as severity scales; working towards inclusion of all modalities with an emphasis on brachytherapy, interventional radiology, and therapeutic nuclear medicine; implementing prospective risk analysis methods;
8) strengthen radiation safety culture in health care by recognizing leadership as a critical element; fostering cooperation between regulatory and health authorities and professional societies; learning about best practices in other areas such as nuclear power and aviation industry; integrating radiation protection in health technology assessments; working towards recognition of medical physics as an independent profession in health care, with radiation protection responsibilities; enhancing information among peers on radiation protection utilizing advances in information technology;
9) foster an improved radiation benefit-risk-dialogue among health professionals, patients and the public; improving risk communication skills involving technical and communication experts; working towards informed decision making for patients;
10) strengthen the implementation of safety requirements globally; developing guidance for the implementation of the International Basic Safety Standards in health care; establishing sufficient legislative and administrative framework for the protection of patients, workers and the public at national level, including enforcing and performing on-site inspections to identify deficits in the application of the requirements.

The IAEA and WHO are currently working in close cooperation to support the implementation of these ten priority actions in Member States. Several other international organizations and professional bodies have taken into account those priority actions to develop their strategic plans on radiation protection.

CONCLUSIONS

Diagnostic, interventional and therapeutic use of ionizing radiation is beneficial for hundreds of millons of people each year in enhancing human health and welfare, and thus, among the peaceful uses of radiation, medical exposure is, by far, the most predominant. Unnecessary exposure of patients can arise from medical procedures that are not justified for a specific clinical objective, and from procedures that are not optimized for the situation in which they are being used. Unintended and accidental exposure can arise from unsafe design or inappropriate use of technology, mainly in interventions guided by radiation imaging and therapeutic applications of radiation.

In March 2001, an International Conference on the Radiological Protection of Patients was held in Malaga, Spain, which led to an international action plan for the radiation protection of patients. Ten years after establishing the international action plan, the "International Conference on Radiation Protection in Medicine: Setting the Scene for the Next Decade" was held in Bonn, Germany, in December 2012. The main outcome of this conference was the so called "Bonn Call for Action" that identifies priority actions to enhance radiation protection in medicine for the next decade, which identifies ten priority actions.

The IAEA and WHO are currently working in close cooperation to foster and support the implementation of these ten priority actions in Member States. Several other international organizations and professional bodies have taken into account those priority actions to develop their strategic plans on radiation protection. Implementation require collaboration of national governments, international agencies, researchers, educators, institutions and professional associations as well as harmonization and co-ordination of activities at an international level.

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