IAEA ACTIVITIES ON RADIATION PROTECTION IN DIAGNOSTIC IMAGING

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IAEA statute: “To establish or adopt ... standards of safety for protection of health and minimization of danger to life ... and to provide for the application of these standards”
IAEA is the focal point for all issues related to radiation protection in medicine.

Diagnostic and interventional radiology

Nuclear medicine

Radiotherapy
Learning objectives

- Summarize the basic requirements of the International Basic Safety Standards related to diagnostic imaging.
- Learn about tools provided by the IAEA to support implementation and to strengthen radiation protection of patients and staff.
- Learn about outcomes of the IAEA projects related to radiation protection in diagnostic radiology and nuclear medicine.
Benefits of the use of radiation in medicine

- The use of radiation in medicine has brought tremendous benefits to the global population
- More can be done with radiation in medicine
  - More equipment
  - More complex equipment
  - New technologies and techniques
  - New role
- Access vary around the world
- Issues vary around the world
- Tailored approaches needed
Global trends and issues

• Global increase of the use of radiation

• Growth of high-dose procedures: CT, interventional SPECT-CT, PET-CT

• A significant fraction (20-50% in some areas) of radiological examination may be medically inappropriate/unjustified

• Large variations of patient doses between different centres

• Increased individual patient doses from diagnostic exams
  o Repeated exams
  o Individual doses over 100 mSv
  o Increased cancerogenic risk at these doses
Do more good than harm

Radiation saves lives

Radiation can cause harm

Short-term effects (deterministic)
- Carcinogenesis
- Hereditary effects
- Effects in the embryo/foetus

Long-term effects (stochastic)
- Carcinogenesis
- Hereditary effects
- Effects in the embryo/foetus
International system of radiation protection

**Exposure situations**
- Planned
- Emergency
- Existing

**Categories of exposure**
- Medical
- Occupational
- Public

**Principles:**
- Justification
- Optimisation
- Dose limitation

**Requisites**
- Information
- Assessment of exposure
- Stakeholders involvement

**Dose criteria**
- Dose limits
- Dose constraints
- Reference levels
International Basic Safety Standards (BSS)

Published July 2014

Co-sponsors:

- Not mandatory
  - No obligation for States to bring legislation into conformity, etc.
- However
  - Mandatory for Member States receiving technical assistance from IAEA
  - Used as a template for many national regulations
BSS: Responsibilities for protection and safety

**Government** - establishment a legal and regulatory framework

**Regulatory Body** – establishment or adoption regulations and guides for protection and safety and establishment a system to ensure their implementation

**The principal parties responsible for protection and safety:**
- Registrants or licensees
- Employers, in relation to occupational exposure;
- Radiological medical practitioners, in relation to medical exposure

**Specified responsibilities:**
- Suppliers of sources, providers of equipment and software;
- Qualified experts and Radiation protection officers
- Health professionals
- Ethics committees
BSS: Health professionals

Radiological medical practitioner
Medical radiation technologist
Medical physicist
Radiopharmacist

Competence is normally assessed by the State by having a formal mechanism for registration, accreditation or certification.
BSS Req. 37. Relevant parties shall ensure that medical exposures are justified.

BSS Req. 38. Registrants and licensees and radiological medical practitioners shall ensure that protection and safety is optimized for each medical exposure.
### BSS: Justification of medical exposures

#### 3 levels of justification of medical exposure

<table>
<thead>
<tr>
<th>Level</th>
<th>Scope</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1</strong></td>
<td>General justification of the use of radiation in medicine</td>
<td>Taken for granted – accepted as doing more good than harm</td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
<td>Generic justification of a given radiological procedure</td>
<td>Health authority in conjunction with appropriate professional bodies</td>
</tr>
<tr>
<td><strong>Level 3</strong></td>
<td>Justification of medical exposure for individual patient</td>
<td>Consultation between the radiological medical practitioner, and the referring medical practitioner</td>
</tr>
</tbody>
</table>
BSS: Optimization of protection and safety

Design considerations for equipment

Quality Assurance

Calibration

Operational considerations

Dosimetry of patients

Diagnostic Reference Levels (DRLs)
BSS: Optimization of protection and safety

Particular attention to be taken for justification of exposure and optimization of protection for:

- Paediatric patients
- Embryo or fetus (pregnant female)
- Breastfed infant (from procedure with radiopharmaceutical performed to mother)
BSS: Unintended and accidental medical exposures

• **Prevention:** All practicable measures are taken to minimize the likelihood of unintended or accidental medical exposures.

• Registrants and licensees shall promptly **investigate** unintended or accidental medical exposures and, if appropriate, shall implement **corrective actions**.

• Licensee must keep a **record**

• Reporting to Regulatory body limited to significant events or as required by the Regulatory body
BSS: Radiological review

• A requirement for **radiological review** introduced

Radiological review: A systematic examination or review of the radiological procedures being performed in a given medical radiation facility, that seeks to improve the local implementation of the radiation protection principles of justification and optimization.

• Responsibility of the radiological medical practitioners
From standards to practice

• Difficulties:
  - medical domain
  - requires cooperation between regulatory body, health authority, professional bodies

• Barriers:
  - lack of awareness
  - self-referral
  - defensive medicine
  - self-presentation
  - financial, social, or medico-legal pressures
The International Action Plan (2002)
• born in the Málaga Conference (2001)

The Bonn Call-for-Action (2012)
• Bonn conference (2012)
• joint position statement with WHO highlights 10 main actions for the strengthening of radiation protection in medicine over the next decade

Next IAEA conference on Radiation Protection in Medicine in 2017, Q4
IAEA activities to support implementation

- Providing standards
- Providing training
- Providing guidance
- Facilitating knowledge exchange
- Giving technical assistance
- Building awareness

- Training courses
- Safety standards
- Safety reports
- Technical documents
- Public website
- Meetings
- Workshops
- Scientific visits
- Reporting systems
- Scientific publications
- Scientific visits
- Involve in projects
- Fellowships
- Providing tools
- Direct advice
- Assessments
- Missions
- Information campaigns
- AAA International campaign
- Awareness, Appropriateness, Audit
Providing guidance – safety guide

Safety Guide on Radiation Protection and Safety in Medical Uses of Ionizing Radiation

- Under development
- Cooperation in developing from international / regional organizations
- Expected to be co-sponsored by WHO, PAHO, ILO
- 2015 – 2016: target publication

- How the BSS applies to facilities
- Aimed at (primarily):
  - End-users: Medical radiation facilities: “What do I need to do to ensure that my facility’s medical uses of radiation are in compliance with the BSS”
  - Regulatory Bodies: “What do the Government need to do to ensure that the facilities in the country meet the requirements of the BSS”
Safety Reports and TECDOCs

• Safety reports: specific guidance and lessons-learned
  (1) PET/CT; (2) Guidance levels in interventional procedures; (3) Cardiac CT; (4) CT Colonography and (5) Release of Patients after Radionuclide Therapy; (6) Radiation Protection in Paediatric Radiology

• TECHDOCs: state-of-the-art information on specific topics
• Available from www.iaea.org
Providing guidance - website

- Dedicated public website – http://rpop.iaea.org

Updated monthly

Information for
- Health professionals
- Member States
- Patients

Additional resources
- Publications
- Safety Standards
- Training material
- Posters
Providing guidance – training material

- Training material (free download from http://rpop.iaea.org)
Providing training

- Providing training courses
  - Regional training courses
  - National training courses supported
  - Main target audience: health professionals in hospitals; but also radiation protection professionals
Providing guidance – posters and leaflets

- Informational posters and leaflets (in many languages, from http://rpop.iaea.org)
Providing guidance – posters and leaflets
Facilitating knowledge exchange

• Technical meetings
  March 2015: Justification of medical exposure
  April 2015: Patient exposure tracking
  November 2015: Implementation of the BSS and Safety Guide
Facilitating knowledge exchange

- Incident reporting databases
  - Anonymous
  - Voluntary
  - Learning from incidents

- SAFRAD
  - Intervventional procedures

- SAFRON
  - Radiation therapy
Building awareness

• Social networks

https://www.facebook.com/rpop.iaea.org

https://twitter.com/rpop_iaea

4000 likes in Facebook
1200 likes in Twitter
Technical cooperation (TC)

- Regional and national TC projects:
  - High number of countries participating in technical cooperation projects on radiation protection of patients
  - Tasks in all major areas of patient protection
  - Expert missions, direct advice and provision of tools
  - Fellowships
  - Scientific visits
  - Regional and national training courses
## List of Regional Projects on Medical Exposure Control

To obtain information about the participants of each project, enter the Project Number (from this table) in the "Project Information" menu on the [Website of the Department of Technical Cooperation](#) and click on "Go".

<table>
<thead>
<tr>
<th>Region</th>
<th>Project Title</th>
<th>Field</th>
<th>Number</th>
<th>1st year of approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>Strengthening Technical Capabilities for Patient and Occupational Radiation Protection in Member States</td>
<td>12</td>
<td>RAF9053</td>
<td>2014</td>
</tr>
<tr>
<td>Asia</td>
<td>Strengthening Radiation Protection of Patients in Medical Exposure</td>
<td>12</td>
<td>RAS9065</td>
<td>2012</td>
</tr>
<tr>
<td>Asia</td>
<td>Strengthening Radiation Protection Infrastructure and Technical Capabilities for the Safety of Workers, Patients and the Public</td>
<td>12</td>
<td>RAS9075</td>
<td>2014</td>
</tr>
<tr>
<td>Europe</td>
<td>Strengthening Member State Technical Capabilities in Medical Radiation Protection</td>
<td>12</td>
<td>RER9132</td>
<td>2014</td>
</tr>
<tr>
<td>Latin America</td>
<td>Strengthening National Infrastructure for End-Users to Comply with Regulations and Radiological Protection Requirements</td>
<td>12</td>
<td>RLA9075</td>
<td>2014</td>
</tr>
</tbody>
</table>
## National Projects

To obtain more information about any of the national projects on medical exposure, visit the [Technical Cooperation Website](#) and search for the project by country.

<table>
<thead>
<tr>
<th>Member State or Observer</th>
<th>Project Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>Establishing a Medical Exposure Control Programme to Avoid Unnecessary Exposure of Patients</td>
</tr>
<tr>
<td>Bahrain</td>
<td>Improving Radiological Protection of Patients</td>
</tr>
<tr>
<td>Bosnia and Herzegovina</td>
<td>Strengthening Radiation Protection in Medicine</td>
</tr>
<tr>
<td>Brazil</td>
<td>Supporting National Assessment of Quality Control and Radiation Protection in Interventional Cardiology Departments</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>Strengthening of Quality Management and Radiation Protection in Nuclear Medicine, Radiology and Radiotherapy at the Caja Costarricense de Seguro Social</td>
</tr>
<tr>
<td>Lithuania</td>
<td>Supporting Long Term Recording of Patient Doses in Diagnostic and Interventional Procedures</td>
</tr>
<tr>
<td>Mauritania</td>
<td>Strengthening Capacities for the Protection of Workers, Patients, the Public and the Environment against Ionizing Radiation</td>
</tr>
<tr>
<td>Mali</td>
<td>Enhancing the National Radiation Protection Infrastructure for Workers, Patients and the Environment</td>
</tr>
<tr>
<td>Morocco</td>
<td>Improving Quality Management Systems for Regulatory Body Activities for Sustainable Radiological Protection of Workers, Patients, the Public and the Environment</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>Strengthening Occupational and Medical Radiation Protection through Improving Human Resource Capabilities and Infrastructure of the Radiation Physics and Metrology Laboratory (UNAN-Managua) and Establishing a National Dose Register</td>
</tr>
<tr>
<td>Palestine</td>
<td>Supporting Education and Training in Radiation Protection and Medical Physics</td>
</tr>
<tr>
<td>Senegal</td>
<td>Strengthening Capacities for Monitoring Radiation Protection in Medical Settings</td>
</tr>
<tr>
<td>Singapore</td>
<td>Developing a National Medical Guidance Dose Code of Practice</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>Strengthening Radiation Protection in Diagnostic Radiology and Promoting Audit and Safe Use of Diagnostic Medical Radiation</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>Strengthening the National Programme on Patient Radiation Safety and Dosimetry</td>
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</table>
Publications from the TC projects

IAEA Survey of Pediatric CT Practice in 40 Countries in Asia, Europe, Latin America, and Africa: Part 1, Frequency and Appropriateness

Jenia Vassileva, Madan M. Rehani, Humoud Al-Dhuhl, Huda M. Al-Naemi, Jamila Salem Al-Suwaidi, Kimberly Appelgate, Bieganski

IAEA survey of paediatric computed tomography practice in 40 countries in Asia, Europe, Latin America and Africa: procedures and protocols

OCCUPATIONAL AND PATIL IN INTERVENTIONAL CARD AND HERZEGOVINA

A. Beganović, B. Bašić, M. Gazdić-Šantić, and D. Samek

Radiation Protection Dosimetry (2011), pp. 1–4

A STUDY TO ESTABLISH INTERNATIONAL DIAGNOSTIC REFERENCE LEVELS FOR PAEDIATRIC COMPUTED TOMOGRAPHY


Sotiris Economides

Radiation Protection Dosimetry (2015), Vol. 165, No. 1–4, pp. 70–80

Advance Access publication 1 April 2015

doi:10.1093/rpd/nct1601
Launched September 2015
To survey the practice in less resourced countries
To identify need of actions
Preliminary analysis:
- Answers from 15 countries (13 from Europe, 1 Latin America, 1 Asia)
- Nuclear medicine physicians, medical physicists, technologists
- 27% use SPECT/CT
- 31% use PET/CT
- 42% use both
Survey on Radiation Protection in Hybrid Imaging

Radionuclides used for:

### SPECT
- TI-201: 6%
- Cr-51: 6%
- Ga-67: 12%
- In-111: 18%
- I-123: 59%
- I-131: 82%
- Tc-99m: 100%

### PET
- Ga-68: 8%
- Rb-82: 8%
- N-13: 8%
- C-11: 42%
- F-18: 100%
Survey on Radiation Protection in Hybrid Imaging

Most frequently performed examination

**SPECT/CT**
- Myocardial Perfusion Imaging, 12%
- Bone Imaging, 88%
- Lung Perfusion Imaging
- Renal Imaging
- Thyroid Imaging
- Brain Imaging

**PET/CT**
- PET/CT scan of the torso, 35%
- Whole body PET/CT scan, 65%
- Brain PET/CT scan
- Limited-area tumour imaging
- Myocardial perfusion imaging
Survey on Radiation Protection in Hybrid Imaging

Type of CT scanner in the SPECT/CT
- CT scanner with diagnostic capability: 41%
- CT scanner for attenuation correction: 59%

Type of CT scan included in the PET/CT acquisition protocol for tumour imaging
- Both: 35%
- Low-dose CT scan: 59%
- Diagnostic CT scan: 6%
Survey on Radiation Protection in Hybrid Imaging

Diagnostic reference levels available?

- Yes: 50%
- No: 39%
- Don't know: 11%

Do you perform comparison between DRLs and typical values in your facility?

- Yes: 67%
- No: 33%
Survey on Radiation Protection in Hybrid Imaging

Typical activity of $^{99m}$Tc-DMSA for renal imaging?

a) For an adult patient (70 kg)
   - 74-80 MBq: 27%
   - 100-150 MBq: 46%
   - 185-200 MBq: 20%
   - 925 MBq: 7%

b) For a paediatric patient (30 kg)
   - 11 MBq: 7%
   - 45-50 MBq: 50%
   - 65-74 MBq: 21%
   - 111-124 MBq: 15%
   - 444 MBq: 7%

6-68% from adult activity
Recommended (EANM) 47 MBq
Survey on Radiation Protection in Hybrid Imaging

Typical activity of FDG for a whole body PET/CT scan

a) For an adult patient (70 kg)

Activity, MBq

- 200-220: 19%
- 250-260: 13%
- 280: 25%
- 300-310: 31%
- 370-380: 12%

b) For a paediatric patient (30 Kg)

Activity, MBq

- 90-100: 31%
- 105-115: 15%
- 133-150: 23%
- 170-180: 31%

27-61% from adult activity
### Survey on Radiation Protection in Hybrid Imaging

**Procedures followed for a female patient regarding pregnancy before the administration of radiopharmaceuticals?**

<table>
<thead>
<tr>
<th><strong>SPECT/CT</strong></th>
<th><strong>PET/CT</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask the female patient if her menstrual period is overdue</td>
<td>Ask the female patient if her menstrual period is overdue</td>
</tr>
<tr>
<td>Optimize and modify the SPECT and CT protocols in order to minimize the fetal exposure</td>
<td>Optimize and modify the SPECT and CT protocols in order to minimize the fetal exposure</td>
</tr>
<tr>
<td>Ascertain if a female patient is pregnant (pregnancy test or hormonal level determination)</td>
<td>Ascertain if a female patient is pregnant (pregnancy test or hormonal level determination)</td>
</tr>
</tbody>
</table>

- **SPECT/CT**:
  - Ask the female patient if her menstrual period is overdue: 44%
  - Optimize and modify the SPECT and CT protocols in order to minimize the fetal exposure: 6%
  - Ascertain if a female patient is pregnant (pregnancy test or hormonal level determination): 11%

- **PET/CT**:
  - Ask the female patient if her menstrual period is overdue: 87%
  - Optimize and modify the SPECT and CT protocols in order to minimize the fetal exposure: 13%
  - Ascertain if a female patient is pregnant (pregnancy test or hormonal level determination): 33%
Period of interruption of breast-feeding after administration of:

- I-123 NaI for thyroid scan
  - Complete cessation
  - Interruption of 60h
  - Interruption of 48h
  - Interruption of 24h
  - Interruption of 12h
  - Interruption of 4h
  - NA

- Tc-99m pertechnetate for thyroid scan
  - Interruption of 60h
  - Interruption of 48h
  - Interruption of 24h
  - Interruption of 12h
  - Interruption of 4h
  - NA

- Tc-99m MIBI for a myocardial perfusion
  - Interruption of 4h
  - NA

- Administration of FDG
  - Several days
  - Interruption of 24h
  - Interruption of 6h
  - Interruption of 4h
  - No interruption
  - NA
Conclusions from the survey (preliminary):

• Variation in practice between departments
• BSS requirements not fully implemented
• Further practical guidance needed
• Training needed of medical staff on optimization strategies in hybrid imaging
• Results will be used in planning the future activities under the TC program 2016-2017

• New activities:
  • E-learning material
  • Webinars
  • New posters and information material
Conclusion

• Medical uses of ionizing radiation only have a place in the context of medical practice. The system for ensuring radiation protection needs to fit in with the larger system for ensuring good medical practice
• The International BSS set basic requirements for protection and safety
• Implementation is a challenging task; reaching stakeholders and making efforts effective and lasting is complex
• A systematic approach should be applied to ensure that there is a balance between being able to utilize the benefits from medical uses of ionizing radiation and minimizing the risk of radiation effects to patients, workers and members of the public
• The IAEA addresses these issues globally, in co-operation, through the International Action Plan, in a variety of actions
• The MS are welcome to contribute and use available resources