Summary of the IAEA Technical Meeting on the Justification and Optimization of Protection of Patients Requiring Multiple Imaging Procedures, held online 19-23 October 2020

The IAEA Technical meeting was held 19-23 October via the online platform WebEx. The meeting agenda is in the Annex. The meeting was attended by 93 participants and experts representing 32 Member States, as well as 13 international organizations and professional bodies: ICRP, WHO, UNSCEAR, European Commission, HERCA, FDA, ISR, ISRRT, IOMP, ESR, EFOMP, Image Gently, and DITTA. Meeting participants represented a wide spectrum of specialties – radiation effect scientists (radiobiologists, radiation epidemiologists), medical industry, scientists involved in technology developments, referring physicians, imaging physicians, medical physicists, technologists/ radiographers, radiation protection specialists and regulators. Two patient champions from the WHO Patients for Patient Safety network also participated.

This meeting was a continuation of the first IAEA Technical Meeting on Radiation Exposure of Patients from Recurrent Radiological Imaging Procedures, held 4-6 March 2019 at the IAEA Headquarters, VIC, Vienna. The results of this first meeting have been reflected in the scientific paper published in the journal European Radiology (Brambilla et al, 2020).

The following report summarizes the findings and conclusions from the meeting.

Observations

Following the call for action promoted in the first meeting, much evidence has emerged in the scientific literature on recurrent imaging.

- Large scale studies covering >400 hospitals in 20 countries demonstrated that there is a sizable number of patients (between 0.5 and 3.5% of all who undergo CT exams, around 1 % on average) who receive a cumulative effective dose (CED) over 100 mSv in a short period of their life. At the level of CED > 100 mSv there are several organs receiving dose > 100 mGy. Around 20% of the patients in this group are under 50 years old. Some patients get 100 mSv in a single procedure or in a single day.
- There is currently limited data on the percentage of patients receiving high CED due to fluoroscopically guided procedures, nuclear medicine examinations, as well as on the total cumulative dose to a patient from different modalities. There is also a lack of data on paediatric patients to make a definite opinion. Dose to tissues outside the tumor volume in oncology patients due to the increased use of imaging is not well studied.
- The available radiation research and epidemiological studies to date provide evidence on the increase of cancer risk with dose for the dose and dose rate range of interest in medical exposure. Interpretation of data from medically exposed groups require care, as exposure occurs because of known or suspected disease and this may affect the risk estimates. Accurate organ dose estimates are often lacking in past studies.
- There are a number of clinical conditions known to potentially lead to recurrent imaging with high dose techniques (list provided in the paper of Brambilla et all, 2020). There are limited studies on assessment of appropriateness of recurrent imaging.
- In general, appropriateness criteria are lacking for serial imaging. When available, referral guidelines/ appropriateness criteria are not well implemented in clinical practice. In many situations that require recurrent imaging, ultrasound (US) or MRI are an appropriate alternative.

- Appropriateness is a complex concept, and to balance cumulative risk against cumulative benefit of imaging, the access to the exposure history of an individual patient might add the decision-making process. Integrating CED into the Clinical Decision Support (CDS) requires creating a better understanding of how CED should or should not be used.
- Although the benefits of imaging are difficult to quantify, they are likely decreasing in repeated imaging. Therefore, the attention needs to be on the frequency of imaging and the common cause of recurrent imaging.
- The technological developments to decrease dose through hardware and software development are significant. Machine leaning and artificial intelligence (AI) are promising in this regard.
- Automatic exposure monitoring systems have become available in many hospitals, mostly in high income countries, which facilitate exposure history tracking of individual patients in addition to be an effective tool for optimization. Most exposure monitoring systems provide a way to assess effective dose (*E*) and CED in individual patients with the understanding that it represents dose to representative phantoms.
- The conversion factors used to calculate *E* from modality-specific metrics in exposure monitoring systems are not standardized and there can be significant differences in values of *E* derived with different phantoms, and the uncertainties associated could be high.
- *E* can be used for summing doses from multiple examinations, but when considering risk, the age, sex, and health of patients should be taken into account. "Personalized" organ dose estimates which take into body size and shapes are getting introduced in dose monitoring systems, and this is an area of further development and standardization.
- A survey among health professionals of different groups showed that the previous exposure history of a patient is perceived as a valuable tool by medical staff and it will benefit rationalizing the decision making for the next exams.
- Some meeting participants expressed concern that if CED is provided to referring physicians or patients, this may lead to miss-interpretation and some may refuse a justified radiological procedure and compromise patient care. It has been emphasized that when communicating any dose information, in particular to stakeholders outside the radiology community, it is paramount to put the dose in the context of the benefit gained from the imaging exam. This requires improved communication between radiological medical professionals, referring physicians of different specialties as well as patients.

Fields for future work

The meeting discussed the following fields that need further work and research studies:

1. **Identifying groups of patients with high CED and enhanced justification and appropriateness**
   - Models need to be developed for predicting patient types with clinical conditions that are likely to accumulate relatively high doses due to recurrent medical imaging. The largest group of oncology patients should be also included in the studies on recurrent imaging.
   - Professional medical and allied societies need to develop and review when available, imaging strategies for patients with long-term illnesses and clinical conditions that require recurrent imaging, in terms of the type of imaging needed and its frequency. Account needs to be taken for the new technologies and new scientific evidences on clinical effectiveness weighed against risks, with preference given to modalities that do not use ionizing radiation such as ultrasound or MRI, as appropriate.
   - When a series of imaging procedures can be reasonably foreseen for a patient, the most appropriate procedures for the patient and the clinical condition need to be chosen, weighing their incidental and cumulative benefits and risks. Clinical and radiation dose information from

all the patient's previous imaging procedures needs to be made available to add to the appropriate decision-making process.

2. **Technological development and dose optimization**
   - The need for further development of lower dose equipment and non-ionizing alternatives is highly emphasized. Dose optimization tools need to be an integral part of the equipment technical specification rather than optional for additional costs. Mechanisms are needed for increasing awareness and adoption of dose-efficient technologies in less resourced countries.
   - Optimized imaging protocols tailored to the patient size and the specific clinical question need to be made available and utilized. This includes baseline imaging protocols for situations requiring recurrent imaging that suffice for clinical needs while minimizing radiation dose. Such imaging situations might often use less dose than other exams for the same anatomical region. Optimization requires involvement of a team of qualified radiological medical practitioners, medical radiation technologists/radiographers and medical physicists.
3. **Dose metrics for tracking exposure history of patients and risk communication**
   - Automatic exposure monitoring systems need to include provision for tracking of exposure history of patients in terms of radiological procedures, cumulative effective dose and patient-specific organ dose metrics.
   - Methods to estimate effective dose need to be standardized, preferably using standardized conversion factors from modality-specific dose metrics to effective dose. Conversion factor development should include an investigation of the parameters with most impact and select an appropriate phantom.
   - Personalized dosimetry is suggested to be included in dose monitoring systems for organ dose assessment and individualized risk estimates, especially when detailed studies are needed, including (but not limited to) cases of recurrent imaging. This would serve future epidemiological surveys as well.
   - Automatic exposure monitoring systems need to be utilized broadly and integrated with other electronic health care systems.
4. **Epidemiological research**
   - Large studies of those undergoing medical exposure, e.g. CT scans, particularly in childhood, offer a good opportunity to study the effects of low doses of X-rays but reverse causation and confounding factors need to be strongly considered.
   - For reliable epidemiological studies, reliable records are needed that are sufficient for meaningful subgroup analyses to be performed. This include records for the reason for imaging, and organ/tissue-specific absorbed doses received during an imaging procedure to be derived.
5. **Radiobiology research**
   - Biodosimetric methods assists the transition to personalized medicine and are a useful tool for quantification of patients' radiosensitivity and radiosusceptibility.
   - Appropriate medical use of low-dose radiation needs to consider individual differences in radiation sensitivity.

The meeting concluded with a consultation and voting on a title and abbreviation of the program of the future work on this topic, and the majority voted for SMARTCARE: Safe Management of Accumulated Radiation Tracking and Customized and Appropriate Radiation Exposure.

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Technical Meeting on the Justification and Optimization of Protection of Patients Requiring Multiple Imaging Procedures

19-23 October 2020
Virtual meeting by WebEx

AGENDA

the indicated time is in Vienna time (CEST)

Monday, 19 October 2020 (Recording of the session here)

Session 1: Opening session and setting the scene		Moderator: J. Vassileva (IAEA)
14:00 – 14:30	Opening and welcome	P. Johnston, Director NSRW M. Abdel-Wahab, Director NAHU
	Summary of the IAEA actions, expectations from the meeting, scope and program. Position Statement.	J. Vassileva, Scientific Secretary
Setting the scene ***Objective:*** *What we currently know about radiation doses and risks in recurrent imaging*		Meeting Chair and moderator: M. Rehani (USA)
14:30 – 15:00	Where do we stand now and way forward in this project	M. Rehani (USA)
15:00 – 15:30	Is there evidence for radiation effects at effective dose of over 100 mSv and organ dose of 100 mGy obtained through intermittent exposures?	W. Rühm (Germany, ICRP)
15:30 – 16:00	Update on quantities for radiation risk estimation in medical imaging and use of effective dose	C. Martin (UK, ICRP) and J. Harrison (UK, ICRP)
16:00 – 16:15	Importance of the clinical perspective to recurrent medical imaging	D. Paez, Section Head NMDI, IAEA
16:15 – 16:30	Q&A, program of the next days and closing of the session	

Tuesday, 20 October 2020 (Recording of the session here)

Session 2: Justification and appropriate use of recurrent radiological imaging procedures ***Objective:*** *Identification of needs for guideline development*		Moderators: A. Sodickson and M. Mikhail-Lette
14:00 – 14:15	Radiation concerns in frequent flyer patients: Balancing cumulative risk against cumulative benefits of imaging	A. Sodickson (USA)
14:15 – 14:30	Experience with assessing imaging appropriateness of patients with 100 mSv+ doses	M. Rehani (USA)
14:30 – 14:45	Gastroenterologist's perspective on recurrent imaging	M. Takenaka (Japan)

14:45 – 15:00	Imaging for Crohn's Disease and appropriateness	O. Pellet (IAEA)
15:00 – 15:15	Appropriate imaging in emergency patients with suspected small bowel obstruction	H. Shokoohi (USA)
15:15 – 15:30	Recurrent imaging in cardiology and appropriateness	A. Einstein (USA)
15:30 – 15:45	Radiology procedures which confer the highest doses: their justification. Following in the imaging footsteps of a liver transplant patient	M. Mikhail-Lette (IAEA)
15:45 – 16:00	Recurrent imaging in paediatrics and appropriateness	D. Frush (USA, Image Gently)
16:00 – 16:30	Panel discussion: Approaches to strengthen the evidence and generate CDS for improved appropriateness of recurrent imaging	Panel: Speakers and F. Kainberger (ESR)

Wednesday, 21 October 2020 (Recording of the session here)

Session 3. Optimization: technological developments, exposure monitoring and tracking ***Objective:*** *Deliberate on technology advances that can result in the optimization of protection for patients with recurrent procedures*		Moderators: M. Brambilla and J. Vassileva
14:00 – 14:50	Recent and upcoming technological developments toward low dose computed tomography	M. Kachelriess (Germany)
14:50 – 15:10	Recent and upcoming technological developments in nuclear medicine	M. Moryson (DITTA) and P. Knoll (IAEA)
15:10 – 15:25	Recent and upcoming technological developments in IR systems	N. Marshall (Belgium)
15:25 – 15:45	What dose monitoring systems offer now and what else is needed?	C. Martel (DITTA) and V. Tsapaki (IAEA)
15:45 – 16:00	Which level of accuracy of dose estimation in dose monitoring systems is available and achievable for patients with high CED?	M. Brambilla (Italy)
16:00 – 16:30	Panel discussion: Action needed to enhance optimal use of technological advances and improve exposure monitoring and tracking	Panel: All speakers

Thursday, 22 October 2020 (Recording of the session here)

Session 4. Improving justification, optimization and communication in clinical settings: learning from experience ***Objective:*** *Learn from local experiences and position of different group of professionals and patients*		Moderators: D. Frush and M. Perez
14:00 – 15:00	Update from countries on patients with recurrent imaging exams	M. Hosono (Japan) S. Dreuil (France) H. Bosmans (Belgium) J. Salem Alsuwaidi (UAE) I. Diakov (Bulgaria) O. Rampado (Italy)

15:00 – 15:10	What referring and radiological professionals want to know about radiation risk and dose from previous exams (survey results)	M. Reim (Estonia)
15:10 – 15:20	What patients who need recurrent imaging want to know?	S. Newell, H. Jafri WHO Patients for Patient Safety network
15:20 – 15:30	Perspective of WHO	M. Perez (WHO)
15:30 – 16:40	Information and actions from professional organizations	G. Frija (ISR, ESR) D. Frush (Image Gently) S. Whitley (ISRRT) P. Ortiz (IOMP) M. Brambilla (EFOMP)
	Position of manufacturers	R. Corridori (DITTA)
	Position of regulators	D. Miller (FDA) H. Waltenburg (HERCA)
16:40 – 17:00	Open discussion on actions of different stakeholders	

Friday, 23 October 2020 (Recording of the session here)

Session 5: What needs to be done: fields for future research ***Objective:*** *Identification of fields for future research on recurrent imaging*		Moderator: M. Rehani
14:00 – 14:25	Fields of epidemiological research	R. Wakeford (UK)
14:25 – 14:50	Can biological dosimetry quantify biological effects of X-ray imaging in patients	O. Belyakov (IAEA)
14:50 – 15:20	Personalised or standardized conversion coefficients between exposure indexes and effective dose in radiology and nuclear medicine?	H. Bosmans (Belgium) and M. Brambilla (Italy)
15:20 – 15:40	Identifying groups of patients with high CED and dealing with the situation, including system of radiological protection	M. Rehani (USA)
15:40 – 16:00	Final discussion and way forward with the Position Statement	
16:00	Summary and closing	Meeting Chair and IAEA