Meeting Report

WHO Lunchtime Seminar on “Radiation Protection in Paediatric Imaging”
Fourth Regional European IRPA Congress Centre International de Conférences Genève (CICG), Geneva, Switzerland

The World Health Organization (WHO) conducted a seminar on Radiation Protection in Paediatric Imaging at the Fourth Regional European Congress of the International Radiation Protection Association (IRPA) in Geneva, Switzerland. The seminar was held on Thursday 26th June 2014. It aimed to increase awareness of radiation protection in paediatric imaging, particularly focusing on procedure justification and optimization. This report summarizes the seminar presentations. The seminar was chaired by Prof Peter Vock from European Society of Radiology (ESR) and co-chaired by Dr Miriam Mikhail of the WHO. Prof Vock opened the seminar by greeting all participants, delivering background remarks and highlights of the topic. The seminar consisted of four sessions, with each of the four speakers introduced in turn by Dr Mikhail.

The first session, “Radiation exposure of children – setting the scene”, was delivered by Dr Maria del Rosario Pérez from the WHO. Dr Pérez emphasized that children are more vulnerable to radiation exposure than adults. They have longer life-span to develop long-term radiation-induced health effects like cancer and have different tendencies to develop cancers compared to adults. Appropriate clinical indications are important when assessing the potential need for paediatric imaging procedures. Referring physicians and radiologists play important roles in this regard. Studies demonstrated that most medical doctors underestimate the radiation dose delivered during a CT scan. Moreover, rapid development in health technology has become a double-edged sword. On one side, health technology has markedly improved our diagnostic capacity. On the other hand, radiological medical procedures confer some risk, particularly for children, and must be used judiciously. Imaging in general has to be more patient-driven rather than technology-driven, for adults as well as children. Health risks must be minimized while maximizing the benefits. To avoid unnecessary exposure, clear justification is needed as to why an imaging procedure is necessary for diagnosis or treatment. Additionally, procedure optimization enables the best result at the lowest possible radiation dose. Appropriate protocols for children are sometimes overlooked whereas this is essential for preventing unnecessary radiation exposure. New data about cancer risks from paediatric CT have been recently published. The UNSCEAR 2013 report: - Effects of radiation exposure of children has reviewed data about 23 different cancer sites and concluded that children are more radiosensitive than adults for 25% of them, including leukaemia, skin, thyroid, breast and brain cancer. Justification of medical radiological procedures and optimization of protection and safety are particularly addressed in the new international radiation basic safety standards – BSS- and are two of the ten priorities actions to improve radiation protection in medicine identified in the Bonn Call for Action.

Dr Rainer Wolf, the University Hospital of Bern, Switzerland, presented “Justification – appropriate referral for paediatric imaging.” It was highlighted the necessity of justification of procedures for protecting patients from the overuse of radiation for imaging, taking into account risks vs. benefits, and how referral guidelines are facilitating appropriate medical imaging. Paediatric imaging justification is particularly necessary because of greater vulnerability of children to radiation compared to adults. Low doses of ionizing radiation are indeed potentially harmful to children. The two radiation protection principles for medical exposures are justification of exposure and optimization of radiation protection. Justification of exposure means conducting a careful assessment of the radiation health risks as opposed to the benefits involved in order to ensure appropriate referral. The implementation of justification itself is considered challenging.
Dr Wolf presented results of a survey conducted in Finland entailing unjustified CT examinations in young patients. Justification responsibility falls upon both the referring clinician(s) and the radiologist(s). Proper training for medical professionals is necessary to understand the concept of justification. Parents and/or patients can also facilitate proper justification. The FDA recommends parents to ask the referring physician about the benefits and risks of imaging procedures for their children; for example, how will the exam improve their child’s healthcare or could another alternative exam that does not use ionizing radiation be considered? Risks and benefits of a CT scan were discussed. Adverse outcomes of CT-scans may include radiation-induced cancer risk, false-positive scan results, unnecessary treatment due to over-diagnosis, and anxiety for the patient or their family. (Ref Pearce et al). On the other hand, significant CT benefits include improved diagnostic capacity, improved treatment planning, and better overall disease surveillance. A clinical case study was also presented. In children with suspected acute appendicitis, results of two imaging modalities using non-ionizing radiation: ultrasound (US) and/or magnetic resonance imaging (MRI) were compared to CT (ionizing radiation). The study concluded that both US and MRI delivered a comparable result to CT images. No significant differences existed in time to antibiotic administration, time to appendectomy, negative appendectomy rates, perforation rates or lengths of stay. Several factors which result in unnecessary CTs are: defensive medicine, pressure from the public to use “high-tech” examinations, more availability and accessibility to CT compared to other non-ionizing imaging modalities, financial incentive to perform CTs, lack of knowledge about particular or alternative imaging modalities, and utilization of imaging instead of adequate clinical assessment due to time pressures. Lastly, Dr. Wolf emphasized that referral guidelines are available in many countries. Clinical Decision Support (CDS) systems can integrate referral guidelines into the process of requisition of a radiologic exam. CDS assists health practitioners with proper justification. However, CDS systems should not replace the role and responsibility of the radiological practitioner with respect to justification.

Dr Claudio Granata from the European Society of Paediatric Radiology, presented “Optimization in Paediatric CT: tips and tricks.” In Europe and the US, 4%-10% of all CT examinations are performed on paediatric patients. Children are more sensitive to ionizing radiation granted their longer life expectancies, larger proportion of red bone marrow, and growing organs with more frequent mitoses. Dr Granata listed points to deliberate when planning a CT-scan for a child. It is necessary to reduce radiation dose as low as reasonably achievable (ALARA) without sacrificing essential information for diagnosis. First, consider alternative imaging methods that do not use ionizing radiation. As mentioned by Dr Wolf, US and MRI are often equivalent or even deliver better results than CT. Second, using a smaller field size by adapting the protocol for children will reduce x-ray photons, thus decrease radiation dose. Image contrast also has to be maintained by adapting protocol, since children have less fatty tissue outlining visceral organs than adults. Children are often uncooperative; movement during dynamic scanning creates motion artefacts, hence reducing image quality and diagnostic capacity. Reassuring and preparing the child prior to scanning may decrease restlessness. Shortening gantry rotation time is also necessary to reduce motion artefacts either from children’s movement or from physiologic motion (breathing, heart beating, peristalsis). Shorter rotation time reduces exposure/scanning time thus decreases the radiation dose. Moreover dose optimization is essential while planning a CT. MDCT scanners are installed with default settings providing flawless standard images and deliver the corresponding standard dose. The standard dose can be optimized substantially; this may cause increased image noise but without any loss in diagnostic performance and/or confidence, in accordance with the ALARA principle. Pitch in multi-slice CT (MSCT) is defined as distance of table movement during 360° gantry rotation.
Higher pitch reduces scan time, dose and motion artefacts. However it increases noise and reconstruction artefacts. Many scanners automatically adjust tube current when pitch changes, without dose reduction. Dual source scanners allow very high pitch with dose reduction and faster scan times. Additionally, increasing beam collimation will decrease radiation dose. Bowtie filters in CT-scanners function as equalization filters that compensate for lack of uniformity of body thickness, thus creating uniform dose distribution and decreasing consequent radiation dose. However, this filter is not user-selectable. As well, centring the child at the centre of the gantry will help avoid asymmetrical exposure. Dr Granata also pointed out that tube current modulation (TCM) should be considered during CT planning. TCM is an adaptive technology that automatically adjusts tube current (mA) to compensate for changes in patient thickness. Many physicians believe that merely turning on TCM reduces patient dose. Proper settings need to be carefully selected for each patient, especially in paediatric imaging. For example, wrong reference values can result in poor image quality or increased dose. Setting the tube current limits also needs to be done carefully. Next, his presentation discussed CT scan protocols. Scan protocols are based on a series of technical settings which affect dose and image quality. Scan protocols are vendor and task specific. Experience with one scanner does not translate into proficiency with another, even from the same vendor. CT protocols are the shared responsibility of radiologists, technologists and medical physicists. Radiologists are responsible for determining scan appropriateness, clinical indication, and subsequent image interpretation. Technologists program the protocols and are most familiar with the scanner(s). Medical physicists have the best understanding of scanner functions, technical factors and their influences on dose and image quality; of the team, they are usually the most knowledgeable regarding dose reference standards and related literature. Paediatric protocols are more diverse as children are smaller and more variable in size compared to adults; tailored radiation dose reduction is necessary. Multiphasic scans are usually unnecessary and result in increased radiation doses. Tube voltage (kV) adjustment also needs to be considered according to patient size. Moreover, further dose reduction is possible for some indications such as hydrocephalus and/or shunt evaluations, craniosynostosis, and urolithiasis. Some examples described by Dr Granata as to proper adaptation of adult protocols for children came from the Image Gently website. The site suggests, for example, varying tube current with age while maintaining constant tube voltage. Another possible method for optimization includes varying tube current with patient size or weight, while altering kV according to patient size. Diagnostic Reference Levels (DRLs) should be considered as a range of reference values intended as advisory levels. Investigation is needed if these values are exceeded. However, DRLs are not a dose limit or index concerning dose optimization or image quality. Very few European countries have established DRLs for CT in children. DRLs for CT in children should be extensively implemented and adopted. Dr Wolfgang Eschner from University Hospital Cologne, Germany, also a member of the physics committee of European Association of Nuclear Medicine (EANM), addressed “Radiation protection in paediatric nuclear medicine imaging”. Dr Eschner pointed out what should and should not be done in paediatric nuclear medicine. Adopting adult image acquisition and processing protocols, and determining administered activity of radiopharmaceutical material by their own algorithms were stated as actions that should not be performed in paediatric nuclear medicine. Dr Eschner pointed out five actions that should be implemented in paediatric nuclear medicine. First, rigorous justification and the use of guidelines. Second, adapt image acquisition and processing protocols. By utilizing enhanced planar processing (EPP) protocols, one can reduce the administered activity by 70% and/or acquisition time by a factor of 4. Another protocol uses an iterative SPECT reconstruction method, for instance Ordered Subset Expectation
Maximization (OSEM). This reconstruction reduced the administered activity by 50% and enhanced lesion detectability. Third, make use of published recommendations for determining the activity to be administered and make guidance easily accessible and useable. EANM published a dosage calculator in 2008. The dosage calculator suggests activity to be administered based upon patient weight and the type of radiopharmaceutical. In addition, the new version of the EANM paediatric dosage card was released in 2014. EANM also released PedDose, and app version of the EANM Paediatric Dosage Card. This application is intended as guidance for nuclear medicine physicians and physicists in determining radiopharmaceutical activity for paediatric patients. Image Gently also provides guidelines from The North American Consensus Guidelines for Paediatric Radiopharmaceutical Administered Doses, in determining radiopharmaceutical activity based on patient weight and the type of radiopharmaceutical. A nuclear medicine radiation dose tool from the Society of Nuclear Medicine and Molecular Imaging (SNMIM) is also available to as a guideline in determining administered activity of radiopharmaceuticals. The fifth action concerns provision of risk-benefit comparisons, for instance a comparison of nominal risk from cancer caused by renal scintigraphy and total lifetime risk of dying from an accident. Finally, an insightful summary and concise discussion were led by the chair, Dr. Peter Vock, and the seminar was closed, gratitude expressed to both the speakers and a full-house in attendance (few hundred). From this seminar, one may conclude that increased awareness of radiation protection in paediatric imaging is a key topic and of great importance in public health fora. Children are more vulnerable to radiation-induced malignancies than adults. Clear justification and optimization are essential when addressing radiation imaging procedures for children. Responsibility for radiation safety in paediatric imaging is shared between referring physicians, radiologists, technologists and medical physicist. Lastly, it is important to provide understandable and accessible referral guidelines to aid health professionals in proper planning of imaging procedures, particularly for children.