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Safety practices in paediatric CT and radiation protection initiatives

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Fast image acquisition and processing achieved with multi-detector CT scanners has resulted in a tremendous growth in the use of CT examinations during the last decade. 15 to 20% of these examinations are performed in infants and children (0-15 years) and the number of repeat scans is increasing (1). Moreover, new generation high-speed multi-detector CT scanners have obviated the need for sedation in children, and have led to the wide use of high-dose examinations. For example, cerebral CTA is frequently performed in paediatric populations with acute onset of neurological deficits. Undoubtedly, the growing use of CT is of great benefit to patients. However, extended radiation usage is associated with an increased risk of radiogenic cancer, especially in paediatric patients. Children are at higher risk for potential harmful radiation effects due to the higher radio-sensitivity and the higher lifetime expectancy compared to adults.

The use of CT examinations must be justified, i.e. the examination must be appropriate and the expected benefits must outweigh the potential risks. All CT examinations should be optimised to achieve the clinical purpose without exposing the patient to more radiation than is necessary. The table summarises the possible techniques to optimise CT examinations performed on paediatric patients. These practical actions must be understood and properly implemented.

Every CT facility should work with a medical physics expert (MPE) in order to measure the radiation output from CT scanners, estimate the radiation dose, monitor doses using dose-tracking methods, maintain patient doses within diagnostic reference levels, reduce doses while maintaining the image quality needed for diagnosis, establish appropriate acquisition techniques, and train CT staff in radiation protection (Figures 1 and 2). MPEs are experts in radiation physics and technology applied to medical exposures and the requirements for the involvement of the MPE in medical exposure procedures have been changed in the newly-published Euratom BSS, increasing their presence in diagnostic and interventional radiology practices (2). Undoubtedly, MPEs can play a major role in CT radiation protection, especially for paediatric examinations. MPEs, radiologists, radiographers and equipment vendors should work together in order to develop effective dose reduction strategies.

The European Federation of Organisations in Medical Physics (EFOMP) is involved in five European tenders related to radiation protection:

- The European Diagnostic Reference Levels for Paediatric Imaging project aims to provide European DRLs for children and promote the use of these DRLs to advance optimisation of radiation protection of paediatric patients, with a focus on CT, interventional procedures using fluoroscopy and digital radiographic imaging. The duration of the project is 27 months and the kick-off meeting of the steering committee took place January 2014.
- The Guidelines on Medical Physics Expert (http://portal.ucm.es/web/medical-physics-expert-project) European Commission project aims to facilitate the harmonisation of the role, and the education and training, of the MPE among the member states of the European Union. The project supports the European Commission in its actions relating to the optimisation of radiation doses to individuals exposed to medical radiation. The results of this project have formed the basis for the development of the Guidelines on MPE, which is expected to be published by the European Commission in the beginning of 2014. MPE guidelines give the requirements in radiation protection in terms of knowledge, skills and competences for the medical physicist working with ionising radiation. Radiation protection of the paediatric patient is included in the key activities and responsibilities of MPEs. Thus, MPEs should supervise procedures for paediatric investigations in relation to dose optimisation. MPEs are also responsible for advising on protocol modifications for each imaging modality in paediatric imaging with respect to diagnostic effectiveness and safety.
- The European Training and Education for Medical Physics Experts in Radiology project (EUTEMPE-RX, www.eutempe-rx.eu) has created a network of excellent teaching centres to provide the best possible training opportunities for European medical physics professionals to become MPEs working in diagnostic and interventional radiology. EFOMP is the main contributor to this project, which officially started with a kick-off meeting in September 2013 in Leuven, Belgium. Among the main tasks of this project is to develop a specific training programme for the MPEs working in diagnostic and interventional radiology. Twelve modules have been selected, each addressing one specific theme. The 'Dosimetry from conceptus to the adolescent' module will address dosimetry and radiation protection methods associated with radiological examinations for children and adolescents.
- The Medical Radiation Protection Education and Training (MEDRAPET, www.medrapet.eu) project aims to a) devise and implement an EU-wide study in order to establish the status and legal and practical arrangements in the member states regarding radiation protection education and training of medical professionals and b) draft and maintain standard European sets of competences at various levels for radiation protection education and training. The results of this project, which ended on March 2012, have formed the basis for the revision of the EC Radiation Protection 116 Guidelines. Healthcare professionals involved in paediatric procedures, need to have specific knowledge, skills and competences (KSC) in order to assure adequate protection of infants and children from routine diagnostic and interventional procedures utilising ionising radiation. The learning objectives specified in the MEDRAPET guidelines include the necessary KSC for paediatric examinations. To maintain European guidelines on education and training in radiation protection for medical exposures, the societies involved created a permanent multidisciplinary working party.
- The European Medical ALARA Network (EMAN, www.eman-network.eu/) aims to build a bridge between researchers, health professionals and policy makers and to provide a platform for EMAN network partners. The EFOMP is a consortium member in this project, which ended on September, 2012. To sustain the network, the societies involved signed a letter of intent to continue collaboration after the project ends. EMAN has focused on the justification and optimisation of pediatric examinations. For these practices, justification and indication for the examination are of paramount importance. Practical approaches to paediatric CT are discussed in the 'WG 1: Optimisation of Patient Exposure in CT Procedures – Synthesis Document' that can be found on the EMAN website.

Table 1: Techniques for reducing radiation dose in paediatric MDCT

Adjust CT acquisition settings for paediatric patients so that dose estimates are no greater than the corresponding adult doses regardless of the patient's size. Reduce x-ray tube voltage, use high pitch values, minimise scanning length, and avoid multiple phases.
Activate automatic exposure control (AEC). AEC has been associated with substantial reduction in patient radiation dose. However, studies show that the dose reduction values achieved in paediatric examinations were substantially lower than those achieved for the adult patients and in a few cases a dose increase rather than decrease was observed.
Use iterative reconstruction (IR) algorithms. Statistical IR methods influence image noise. Model-based IR methods lead to noise and artefact reduction and allow for higher dose reduction than statistical methods.
Exclude radiosensitive organs from the primary beam if at all possible
Inappropriate patient centring may considerably increase image noise, increase dose and cause misoperation of AEC systems. Studies have shown that mis-centring considerably affects organ doses and measured image-quality parameters in paediatric examinations.
In-plane shielding can reduce radiation dose to organs and tissues of the body. However in many cases, shields can impair image quality and produce artefacts.
Patient radiation dose due to z-overscanning may be considerable. For scanners with 64 or more detector rows, z-overscanning is much greater, since the extent of overscanning increases as pitch or beam collimation increases.

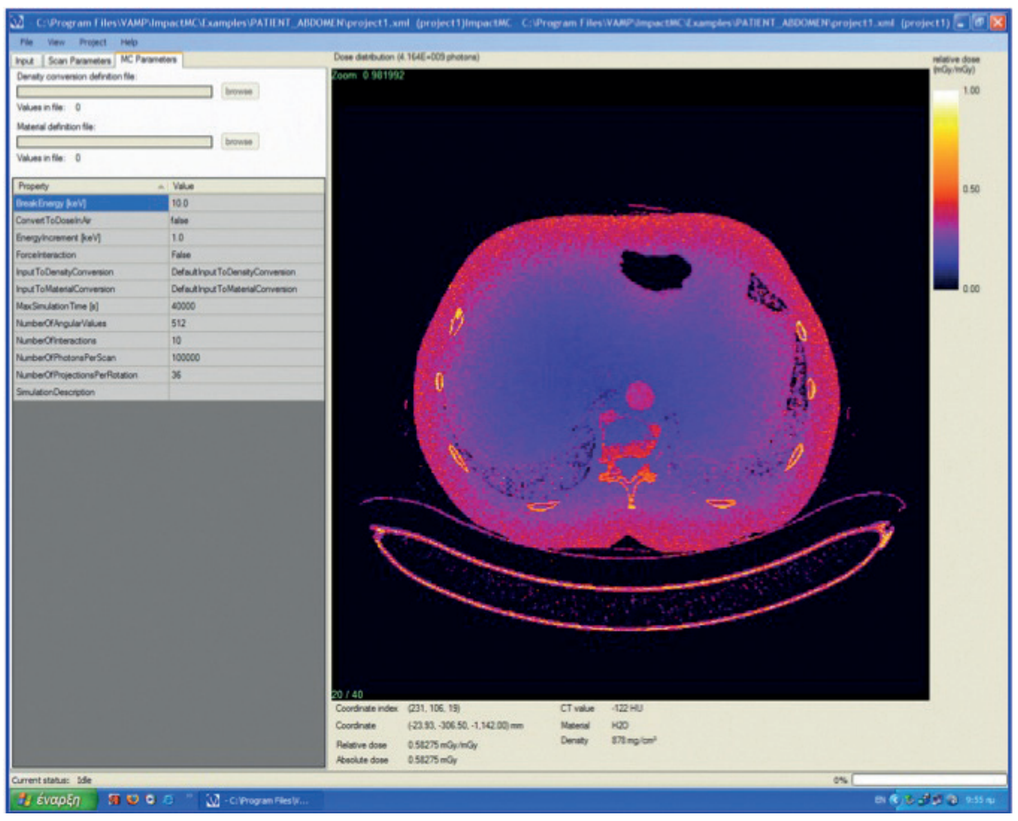

Figure 1: A dose image generated from patient-specific Monte Carlo simulation.

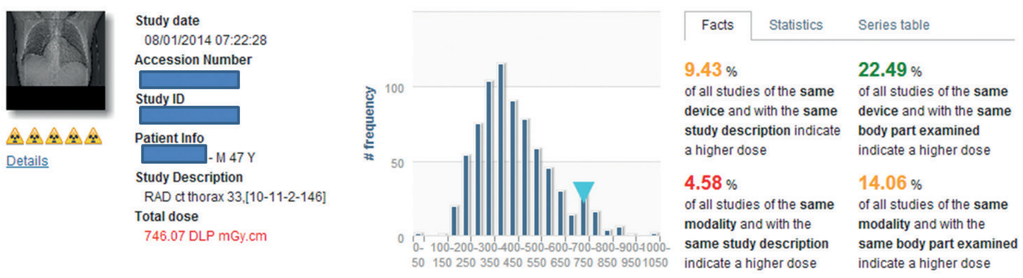

Figure 2: Using an automated online dose monitoring system, it is possible to (remotely) monitor the doses of all patients undergoing x-ray exams in a room of interest. Current example shows the exposure data of a patient plotted in the dose distribution of similar studies performed in the same room. The patient can be categorised as an outlier.

MEDRAPET Medical Radiation Protection EDUCATION AND TRAINING · MPE MEDICAL PHYSICS EXPERT · European Commission · eman European Medical ALARA Network · EUTEMPE-RX · EFOMP

Poster References:

1. International Commission on Radiological Protection, ICRP, 2007. Managing Patient Dose in Multi-Detector Computed Tomography (MDCT). ICRP Publication 102. Ann. ICRP 37 (1).

2. Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, and repealing Directives 89/618/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, Official Journal of the European Union of 17/1/2014.