HERCA

Heads of the European Radiological protection Competent Authorities

HERCA Position Paper

The process of CT dose optimisation through education and training and role of CT Manufacturers

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Content

Executive Summary

CT is the most important source of exposures to radiation in most developed countries today. For this reason CT dose optimisation is of great importance. In this position paper four main stakeholders who are involved in CT dose optimisation are identified. These are the CT manufacturers, the medical doctors, the CT technologists and the medical physicists. HERCA has been working together with the CT manufacturers and COCIR since 2010 following a self-commitment provided by COCIR in 2011. A number of dose optimisation and management tools have been developed by the CT manufacturers and are now available on modern CT scanners. These are presented in this paper. The process of CT dose optimisation can only be achieved if all the stakeholders involved work together as a team and are educated and trained in the use of CT dose optimisation and management tools. The CT manufacturers have an important role in this process. They need to ensure that their staff is properly trained, they need to provide proper education and training to the other three stakeholders involved and these three stakeholders need to find the time and be willing to be trained. This is clearly stated in this position paper with the aim of ensuring appropriate and effective use of CT imaging equipment.

1. Introduction

Over the last decade, tremendous developments in CT technology have taken place. The growing use of this technology is of great benefit to individual patients and to society as a whole. However, any increase in medical radiation exposure must be considered from a radiation protection perspective, particularly if the exposures are not justified and optimised properly.

Concerning medical exposures, it is worth noting that the steady increase in collective effective dose observed during the recent years in developed countries is mainly due to CT scanning and that CT is the most important source of exposures to radiation in most developed countries today. The study on European Population Doses From Medical Exposure (DDM2) showed that for the collective effective dose from x-ray procedures, CT yields by far the highest contribution, on average 57,0 % of the dose from all x-ray procedures (range 5,31 –83,1 %)[1].

Radiation exposure is a concern in both adults and children, however children are much more sensitive to radiation than adults as it has been shown in a number of epidemiological studies of exposed populations[2,3,4]. Children have a longer life expectancy than adults and therefore a greater risk of developing cancer as an expression of radiation damage later on in their life. Dedicated paediatric CT protocols can reduce the dose for the children substantially[5,6].

HERCA believes action is required to address the increasing trend of higher medical exposures of the European population. It is therefore the firm conviction of HERCA that all stakeholders involved in the radiological process should play their part in the reduction, where appropriate, of patient dose, whilst ensuring that adequate image quality is maintained.

As the CT manufactures have an important role regarding the development and implementation of tools for dose optimisation, HERCA initiated a dialogue in 2010 with the four main CT manufacturers in Europe (GE, Philips, Siemens and Toshiba) and COCIR, which represents the radiological, electromedical and healthcare IT industry in Europe. As an important result of this process, COCIR and the CT manufacturers were willing to underline their responsibility on patient dose reduction and provided a voluntary self-commitment by 2011 and updated in 2013[7]. Hereby, they committed themselves to actions that offer the potential to achieve this goal.

The actions included:

- The development and implementation of a standardised benchmarking of CT systems by characterising the dose efficiency related to image quality;
- The implementation of dose reduction measures in CT;
- The implementation of dose management and reporting tools;
- The provision of specific training curricula.

2. The legislation's point of view

The Council Directive 2013/59/Euratom[8] states in article 56 on optimisation that "Member states shall ensure that all doses due to medical exposure for radiodiagnostic, interventional radiology, planning, guiding and verification purposes are kept as low as reasonably achievable consistent with obtaining the required medical information, taking into account economic and societal factors." In article 57 of the Directive on responsibilities it is stated that "the practitioner, the medical physicist and those entitled to carry out practical aspects of medical exposures are involved, as specified by Member States, in the optimisation process" and article 58 requires Member States ensure that "clinical audits are carried out in accordance with national procedures ". Clinical audit is an essential tool in developing and demonstrating dose optimisation.

3. The identification of the Stakeholders involved in CT dose optimisation

CT dose optimisation through the use of dose reduction and dose management tools can only be made possible if radiologists and other imaging specialists, medical physicists, CT technologists and CT manufacturers work together as a team[9].

CT manufacturers are responsible for providing the CT end user with:

- The tools required for dose optimisation and management;
- Extensive education and training on the use of these tools.

Medical Physicists together with the CT technologists are responsible for the:

- Quality assurance of the CT scanners;
- Dose optimisation of the CT protocols;
- Patient dose measurements;
- Establishment of Diagnostic Reference Levels (DRLs);
- Investigation of events where a patient receives a dose which is higher than a defined level.

Radiologists and other imaging specialists are responsible for the:

- Justification of the CT examination
- Dose optimisation of the CT examination
- Image quality of the CT examination

The radiologists and other imaging specialists need to work together as a team in the process of optimisation with the medical physicists and the CT technologists as they need to define the diagnostic quality of the CT images that they require, in order to carry out their diagnosis[10]. They need to indicate to the CT technologist which clinical protocol needs to be used according to the clinical diagnoses requested in order to give the patient a dose as low as achievable while obtaining at the same time the required image quality.

While the undertaking is not always identified as a stakeholder, it has a role in ensuring that its' staff has adequate training and education.

4. The identification of CT Dose Optimisation Tools

4.1. Dose reduction tools

A great number of dose reduction features are now available on modern CT scanners. The most important ones being:

- Predefined protocols for adults and children. These protocols are tailored to various body regions and procedures, which include available dose modulation options. Dedicated protocols for children where the X-ray exposure is automatically adapted to the child's size, weight, and age, substantially reduce patient dose.
- Dose modulation options. Automated real-time tube current adjustment provides the best image quality at lowest possible dose. Tube current is automatically adjusted to patient size. Automated tube voltage adjustment, automatically recommends the optimal tube voltage for each individual patient for each specific examination.
- A variety of iterative reconstruction software algorithms support dose reduction while at the same time maintaining diagnostic image quality by providing an image with less noise at a lower dose.

A number of publications have shown that by using these tools the mean Dose Length Product (DLP, indicator for the patient dose) per CT examination can be reduced by between 20 and 70 %, depending on the part of anatomy being examined, thus reducing the patient dose enormously[9,11,12].

CT Manufacturers continue to work with Industry Associations (COCIR, MITA) to asses current "state of the art standard general practice" dose reduction capabilities, and then intend moving to have these capabilities listed in the IEC "particular requirements for the basic safety and essential performance of X-ray equipment for computed tomography" (60601-2-44) making these capabilities part of CT product configurations.

4.2. Dose management tools

Standardised features have been developed which provide the ability for institutions:

- To set dose values which should not be exceeded for each CT protocol. These give the user feedback when a dose is exceeded and tools for effective patient dose management and reporting[13].
- To decide who has access / permission to use the system for clinical or other uses. It also allows the capturing of operator and patient information as well as information related to saved changes in protocols[14].

Dose management tools offer the following benefits[12,15]:

- They allow for the simpler establishment of local and national DRLs by collecting dosimetric data and also can be used to verify compliance with the established DRLs for regular dose measurements;
- They allow for dose optimisation as hospitals have access to the doses delivered to patients after each CT scan and can thus easily change their imaging protocols to give patients less dose;
- They can be used as an indicator of good and bad radiation protection practices and ultimately serve as an education and training tool;
- They allow for large scale dose data capture from CT scanners which can be used in order to establish databases for quality control, dose optimisation and epidemiological studies;
- Immediate access to patients' previous dose records can help the referring physician in the justification process so that patients can avoid having more and unnecessary CT scans.

All COCIR CT manufacturers provide a display of dose metrics and export capability, allowing software programs to produce dose statistics for a scanner or a collection of scanners at a site.

4.3. Dose and image Quality

While dose reduction is extremely important, diagnostic image quality is just as important. For this reason, dose measurement and image quality assessment need to be done simultaneously. Although a lot of effort has already been made to reduce the dose, no standardised method to access the resulting image quality is currently available. The CT industry is currently working on the design of reference phantoms for assessing Low Contrast Detectability and the associated dose level.

4.4. Education and Training

The CT manufacturers propose specific training programs on existing and new dose reduction techniques and on the use of these product features in daily practice. The provision of specific training curricula should ensure that the CT user is well trained on dose optimisation and facilitates dose awareness in daily practice. Manufacturer's training is designed to support customer facilities in an effort to improve operating knowledge and increase the skill level of personnel. These programs consist of a variety of delivery mechanisms such as:

- Hands-on and didactic training to reinforce skills needed to operate equipment;
- Operator Manuals to demonstrate information on dose optimisation tools and dose reduction strategies;
- Information on dose related displays, indices, and where dose information is located;
- Onsite training, classroom instruction, remote instructor-led training and observation, online tutorial self-help, telephone support, white papers and publications, seminars, peer to peer physician training, and industry association educational material.

Education and training is an extremely important tool in the process of dose optimisation and while the CT manufacturers accept their responsibility for maintaining the proper competence levels of their own staff and trainers**,** it is the facilities' responsibility, to assess and maintain their equipment, their own staffs' competency and to make arrangements with the relevant manufacturers for their training requirements as well as enable the staff to participate to training and education[16].

4.5. Audit

Another very important tool in the process of CT dose optimisation are clinical audits. Clinical audits can consider the whole patient pathway including justification and optimisation to ensure optimal benefits of the use of ionising radiation in the radiological department. Once the CT protocols have been optimised in a facility, using the above mentioned tools and DRLs have been established, it is important that the facility carry out regular clinical audits. The EC guidelines on clinical audits[17] recommend an annual internal audit and an external audit every five years. One of the main aims of these clinical audits in optimisation is to ensure that the national DRLs continue to be respected in the facility and to investigate if further dose reduction is possible at a local level, leading in due course to lower DRLs[11].

5. Discussion

The Council Directive 2013/59/Euratom highlights that doses due to medical exposures from radiological examinations, including those from CT, should be kept as low as reasonably achievable while being consistent with obtaining the required medical information. Of course it may be argued that new CT scanners with the latest dose reduction and dose management tools are expensive and that not all clinical establishments can afford them. However it has been shown that also with older generation CT scanners it is possible to optimise the CT protocols so as to obtain a dose as low as reasonably achievable[11]. For this to be possible a well-trained team, on CT dose optimisation, comprising of a radiologist or other imaging specialist, medical physicist, CT technologist and a CT manufacturer's engineer need to work closely together[10].

It may also be argued that training and education on CT dose optimisation costs money and takes time. This is true. However if the stakeholders involved in CT imaging are properly trained, then the use of non-optimised CT protocols and repetition of CT examinations due to the use of a non-appropriate CT protocol can be avoided. Moreover, access to patient's previous examinations, including the imaging studies, avoids repetition of unnecessary, and thus unjustified, CT examinations. In both cases time and money can be saved. However most importantly the best patient care will only be provided to the patient by giving the patient a justified CT examination with a dose as low as reasonably achievable and an image quality sufficient for the clinical goal to be reached.

6. Conclusion

The process of CT dose optimisation is possible if:

- The CT manufacturers provide the necessary tools for dose reduction and management on CT scanners including specific training on dose reduction methods;
- The stakeholders involved in CT imaging are given adequate opportunity to be properly trained and educated on the existence and use of these tools;

To this end, HERCA has initiated regular consultation with COCIR on the reduction of patient radiation exposure in CT. However patient dose reduction while maintaining adequate image quality can only be achieved if these features are available to the CT user and only if the CT user knows how to use them. In this position paper, HERCA has identified four stakeholders who are concerned by the CT optimisation process. Of these four stakeholders, the CT manufacturers were considered initially as they have an important role in providing the tools necessary for dose reduction in CT imaging. As great progress has been made to provide these tools on modern CT scanners, HERCA considers that the three other stakeholders namely the radiologists and other imaging specialists, the medical physicists and the CT technologists need to:

- Be made aware of the existence of these tools;
- Be trained and educated on the use of these tools;
- Make use of these tools in their daily practice.

CT manufacturers should also continue to train their staff (application engineers and technicians) to keep their knowledge up to date according to the rapid technological developments.

These steps will help to ensure appropriate and effective use of CT imaging equipment with continued dose reduction while maintaining diagnostic image quality.

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List of acronyms

CT Computed Tomography

COCIR: The European Association representing the medical imaging, electromedical and healthcare IT industry

DRLs: Diagnostic Reference Levels

DDM: European Population Doses From Medical Exposure

DLP: Dose Length Product

HERCA: The association of the Heads of European Radiological Protection Competent Authorities

IEC: International Electrotechnical Commission

IT: Information Technology

MITA: Medical Information Technology

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