Ask EuroSafe Imaging
Tips & Tricks

Paediatric Working Group

Dose-saving technologies in paediatric radiology

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In a previous Tips & Tricks lesson about “Adaption of protocol parameters to paediatric patients”, it was discussed that …

… periodic comparison of dose parameters (e.g., dose area product, DAP, or dose length product, DLP) with diagnostic reference levels (DRLs) or achievable levels promote optimising imaging practice (for more information about this issue, see lesson “Paediatric DRLs made easy”, September 2018);

… users of medical X-ray devices are obliged by law to continue optimising procedures even in the dose range below the DRLs;

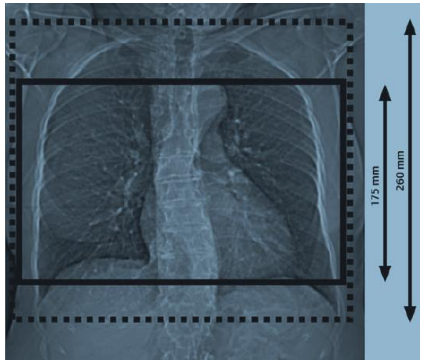
… optimisation is not synonymous with dose reduction.

Optimisation of X-ray procedures in everyday practice means also to *adapt* dose-relevant protocol parameters …

… to the medical question (MQ):

- the MQ determines the body region to be examined and restricts the radiation field in radiographic, fluoroscopic and interventional procedures or the scan length in CT procedures;
- the MQ determines the medical task. According to ICRU report 79, it is distinguished among the tasks detection and localisation of abnormalities, classification, staging (extent of abnormalities and comparison with former stages) and the estimation task (determination of size, shape, intensity of abnormalities);[1]
- the MQ determines whether abnormalities of high- or low-contrast should be detected and examined;

… to a patient's size or weight for examinations of the body or to a patient's age for examinations of the head.



Example for reduced CT scan length to exclude pulmonary embolism.

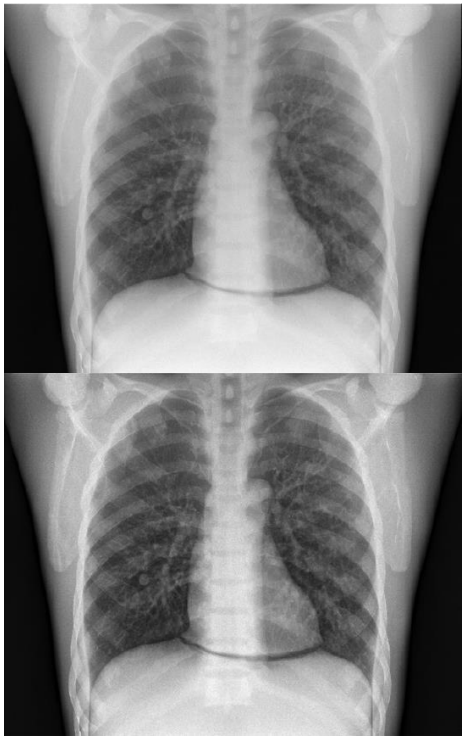
As an additional part of the optimisation process special consideration has to be given to dose reduction measures when purchasing new imaging devices.

- Medical X-ray technology has undergone tremendous developments recently. Various studies have shown the high dose reduction potentials of many of these developments.[2,3]
- Dose-saving measures can be used in combination resulting in a dose reduction of up to 90%.[3]
- Manufacturers of X-ray devices commit to continued innovation and propagation of dose reduction measures and optimized dose management.[4]

Meanwhile, several novel dose-saving measures are considered “state-of-the-art” and are included in the base configuration of modern X-ray devices

Examples of these dose-saving measures that should be used in paediatric radiology are:

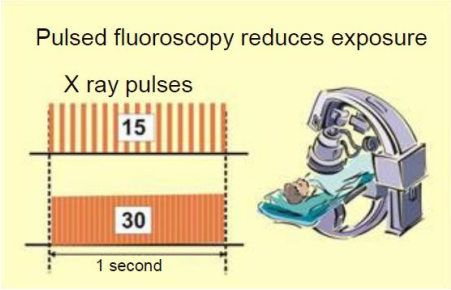
- special image processing tools: reduction of effective dose about 50% using software for correcting scatter irradiation.[5]
- modern detectors with high detective quantum efficiency: reduction of effective dose about 50%.[6,7]
- software providing dose alerts and notifications.
- (basic tools for) dose monitoring/management software.



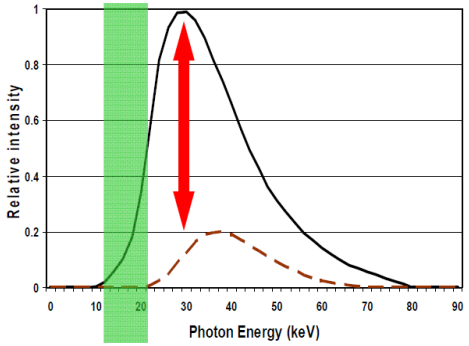
Chest X-ray image without (upper figure) and after software scatter correction.[5]

In paediatric radiography and fluoroscopy, it should be guaranteed that the X-ray device offer …

… availability of pulsed fluoroscopy;
… virtual collimation and patient positioning that helps to perform patient positioning without having to use X-rays simultaneously;[8]
… low attenuation table-tops;
… equipment with the capability for quick and easy removal of anti-scatter grids;
… last-image hold and capture function;
… the possibility to add a copper filters in addition to the aluminum filtration;
… grid-controlled tubes that generate rectangular configurations of the dose rate practically without pre- or post-radiation;
… short exposure times. Optimized short exposure times should be used for paediatric patients to prevent movement artifacts.



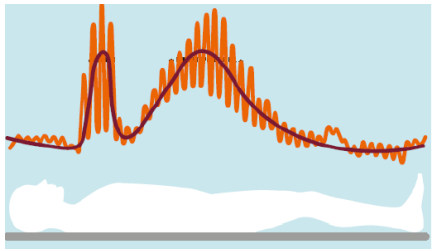
(from IAEA Poster 10 Pearls: Radiation protection for children in interventional procedures)



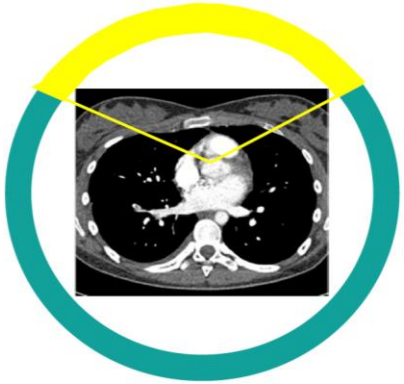
Added filtration reduces the patient skin dose.

In computed tomography (CT) in particular, several novel dose-saving measures have been introduced:

- tube current modulation: reduction of dose up to 60% depending on the anatomical region that is examined and the specific approach of the AEC.[2] Due to the cylindrical shape and the small diameter of the body of children, the dose reduction is lowered compared with adults.[9]
- organ based tube current modulation: reduction of (organ) doses up to 50%.[10] Due to the cylindrical shape and the small diameter, the dose reduction in paediatric radiology is lowered compared with adults.[11]
- automatic kilovolt-selection: reduction of dose up to 50% for contrast material-enhanced scans. Higher dose reduction can be achieved for children compared with adults.[3,12]
- adaptive collimation: reduction of dose up to 60%, e.g. in cardiac CT examinations.[13]



Longitudinal Modulation of tube current (mA) depending on the mean attenuation of the body region (Tips & Tricks CT, Sept 18).



Principle of organ based tube current modulation (Tips & Tricks CT, Oct 17)

In computed tomography (CT) in particular, several novel dose-saving measures have been introduced:

- iterative reconstruction algorithm (IR): reduction of dose up to 45%.[3] Using modern model-based IR, even a dose reduction of up to 80% was claimed for chest CT examinations.[14] However, caution has to be taken when using IR. If the radiation dose is decreased too strongly, the IR algorithm does not preserve low-contrast detectability.[15]

- high-pitch scanning: reduction of dose up to 55%, e.g., in neck CT examinations.[16] Consider that high-pitch examinations strongly reduce the number of cross-section images and, thus, spatial resolution.

- spectral shaping by pre-filtration: reduction of dose up to 20%, [Tips & Tricks CT lesson “Spectral shaping by tin prefiltration”, May 2017].

- high table speeds, high-pitch scanning, and dual source scanners lead to short scans to prevent movement artifacts of the (small) patient.

When purchasing new imaging device for paediatric radiology,[17]

- advice of medical physicists should be sought.
- proper documentation of the purchase orders will make it easier to identify the omission of system components.
- the adequacy of radiological equipment for paediatric imaging have to be ensured.
  - As most imaging equipment is structured to handle adult patients, modifications may be necessary at the installation of the device.
  - Ideally, devices specifically designed for paediatric patients should be installed, especially in facilities with a large workload of paediatric patients.
  - Pre-installed protocols for standard examinations should be tailored to pediatric patients.
  - Protocol parameters should have the broadest range of settings to adapt protocol parameters to the size of the child.

The optimal usage of dose reduction measures requires training.

- Dose reduction measures and new imaging equipment alone do not automatically result in lower doses.
- In general, new imaging technologies have allowed a reduction in radiation dose while improving image quality and diagnostic accuracy, but only after appropriate training and careful monitoring of parameters used in the individual radiology department.
- All team members (physicians, technicians, physicists) should undergo regular training in radiological protection and the correct usage of available imaging equipment.[17]
- Meanwhile, manufacturers offer different workshops and hands-on lessons for the correct handling of their devices. Purchase orders should contain regular (e.g. once per year) training lessons.

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