Ask EuroSafe Imaging Tips & Tricks

CT Working Group

Repeated CT examinations on paediatric patients – what are the risks?

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Background

- Severely ill, mainly neurologic, paediatric patients may undergo multiple head CT scans in a short period of time;
- Clinically, each scan is justified by a pressing diagnostic / therapeutic need;
- The radiologist is, finally, responsible for validating the justification of the exam;
- As exams are repeated over a short timespan, concerns about dose effect, coming from the attending physician and/or the family, are justified.

Background

- Some questions need to be addressed:
  - What are the biological effects to be expected? On the brain? On the lens? On the thyroid?
  - How can we predict them? At what dose?
  - What are the peculiarities for infancy?
  - When does CT become deleterious and it is advisable to abandon?
- Organ dose (Gy) is used to estimate risk for deterministic effects such as skin injury, cataract or hair loss.
- Effective dose (Sv) is used to estimate risk of radiation induced cancer.

Effective dose to a paediatric patient

- There are many different ways of estimating effective dose, the more simplified the method is, the rougher the estimate.
- Dose Length Product (DLP) can be used as a simple estimate of effective dose using only a conversion factor.
- Conversion factors suitable for adults and paediatric patients are available in multiple scientific papers[1].
- $CTDI_{vol}$ and DLP is required by law to be visible to the operator, and stored along with the examination.
- $CTDI_{vol}$ is a estimate of mean absorbed dose in a 16 or 32 cm in diameter Plexiglas phantom, DLP = scan length * $CTDI_{vol}$.

Effective dose to a paediatric patient

Example:

- During 2017 a baby born in November 2016 has 43 brain scans following a hydrocephalus diagnosis. Mean $CTDI_{vol}$=10 mGy and mean DLP=180 mGy*cm per examination.
- A conversion factor with regard to the patients age can for example be found in Romanyukha et al[2].
- From table 1, the suitable conversion factor to use is 0,009.
- Multiplying DLP with the conversion factor results in an estimated effective dose of ~1,6 mSv per exam.
- Performing a more specific estimate using a CT dose software such as CT Expo results in ~2 mSv per exam.

Effective dose to a paediatric patient

- How to translate the effective dose value to an estimate of cancer risk is ambiguous.
- According to ICRP 103[5], the overall risk of a lethal cancer is ~5% per Sv, however, the actual risk varies individually and depends on type of cancer, age and sex.
- Children suffer a 2-3 factor higher risk than adults.

Example:

- 2 mSv times 43 exams equals 86 mSv, which according to ICRP 103, would estimate the risk of a lethal cancer in the future to be ~0,4%, being 2-3 times more sensitive would result in ~1,2%.

Organ dose to a paediatric patient

- Multiple studies show that $CTDI_{vol}$ is a misleading estimate of skin dose and should not be used as such.
- Simple estimations of equivalent dose (organ dose with regard to the radiation (Sv=Gy for x-ray)) can be done using a CT dose software such as CT Expo, ImPACT or VeriDose[3].

Example:

- Using CT Expo and entering scan data such as $CTDI_{vol}$, tube voltage, irradiated volume and tube current, results in an estimate of the organ equivalent dose (Sv) <u>per exam</u>:
  Thyroid = 13,3 mSv (thus 43 exams results in 572 mSv)
  Eye Lens = 13,3 mSv (thus 43 exams results in 572 mSv)
  Brain = 11,5 mSv (thus 43 exams results in 492 mSv)
  Skin = 3,3 mSv (thus 43 exams results in 142 mSv)

Discussion

- According to ICRP 118[6], the threshold for tissue reactions in the eye lens is 0,5 Gy (=500 mSv equivalent dose).
- The example used in this presentation is from a real situation; multiple CT scans on paediatric patients can induce tissue damage.
- The effects of repeated irradiation, even with low dose protocols, should not be disregarded.
- Close monitoring of the cumulative dose should be an important argument in the decision making process of repetitive CT scans.
- Whenever feasible, and when the need of repetitive exams can be foreseen, replacement of CT with noniradiating alternative techniques should be taken into consideration from the very beginning.

Discussion

Doses can be kept as low as reasonably achievable (**ALARA**) if:

- A proper justification is done by a radiologist.
- The dose is adjusted with regard to the size of the patient and the purpose of the examination and specially designed low dose protocols for high contrast anatomy/pathology are used[4].
- The remittent is well informed regarding radiation risks and which medical imaging method is golden standard for the issue referred.
- Doses are kept below paediatric national or international diagnostic reference levels (DRLs).

References

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