Multicenter implementation of a CT scanner dose excellence program based on clinical indication, BMI and diagnostic image quality assessment

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Background

• The revised European Basic Safety Standards Directive (2018) requires:
  • the radiation dose of every CT exam to be recorded with investigation of cases where radiation dose exceeded established reference levels.
  • Radiation protection education and dose optimization training.

• Initial multicenter CT scanner data analysis in Groupe 3R identified:
  • large dose variations,
  • protocol parameters inhomogeneity,
  • lack of staff training uniformity.
Purpose

• Groupe 3R Board priorities (2016)
  • To define and set-up a radiation dose optimization and education program at the group level (7 centers and 7 CT scanners from 3 manufacturers).
  • To implement a “dose culture” by guiding 22 radiologists and 40 technologists towards a change of practice.

Dose Excellence Program: Workflow Diagram

- Stakeholders: Industry, Dose Management Software (DoseWatch™), Medical Physics Expert (MPE)
- Steering Committee
- Team Leader
- Local Dose Teams
- 100% dose excess justification
- Alara
- Optimization
- Indication- and BMI-based protocol map
- CT Field engineer
- 3 NEGATIVE VOTES (2 READERS) OR MPE STOP
- DOSE LEVEL -1 (-12%)
- DOSE LEVEL -2 (-12%)
- DOSE LEVEL -3 (-12%)
- DOSE LEVEL +1 (+12%)
Step 1: Harmonization phase

**Radlex**
- Protocol Radlex mapping
- Design of a clinical indication-based protocol map
- 2 categories of patients for each protocol, according to BMI
- 30 protocols per BMI category

**BMI < 25**

**BMI > 25**

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**Step 1: Harmonization phase**

Acquisition parameters:
- Indication and BMI based
  - Detector configuration
  - Pitch
  - Tube rotation time
  - Tube voltage
  - Tube current modulation
  - Noise index
  - Reconstruction kernel
  - Reconstruction parameters
  - Reconstruction standardization

Purpose
- To deliver a CTDI\textsubscript{vol} value
  - Close to P25 DRL when BMI<25
  - Below P75 DRL when BMI>25
Diagnostic image quality assessment

Radiologists prospectively vote for diagnostic image quality using an electronic voting tool in the dose management software.

A negative vote needs to be confirmed by a second reader using adapted European image quality guidelines.

Step 2: Optimization phase

- Dose reduction phase
  - 12% step-wise mA reduction for all protocols every 50 examinations of the same indication.
  - In case of 3 negative voting for diagnostic image quality per protocol, confirmed by a second reader, dose was increased by 12% to reach previous accepted dose level (ALARA).
  - In parallel, the Medical Physics Expert quantified with a model observer the low contrast detectability using a anthropomorphic phantom (QRM™ 401 abdomen phantom, Germany) to assess at which mA reduction level a 5mm lesion in the liver would not be diagnostically detectable.
Results

- A think tank on image quality related to clinical indication and patient habitus enabled a team commitment in a quality project and a consensual good practice standardization.

- The use of a dose management software combined to Radlex protocol mapping enabled 100% of dose excess justification and protocol comparison in a multicenter setting.

- Protocol harmonization allowed comparison of comparable data (no redundancy), maintained diagnostic image quality and reduced dose by 6% for chest and 7% for abdomen.

- Protocol optimization enabled an additional average dose reduction of 26% (range 20-30%, depending on clinical indication), before hitting the low contrast resolution limit as assessed by phantom measurements.

- Clinical indication- and BMI-based protocols allowed significantly lower dose levels than existing DRL based on anatomical region with a sufficient diagnostic image quality: "The right dose for the right diagnosis".

The complex process of homogenizing CT protocols and optimizing radiation doses without compromising image quality can be achieved with

- A clear roadmap
- Teamwork and education
- Continuous dose monitoring
- Partnership with stakeholders
- Leadership
- Regular communication
- Commitment

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