Code of Practice and recommendations on CT-simulators

NCS subcommittee proposal

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Introduction

CT-simulators used in Radiotherapy consist of a dedicated CT-scanner added with multiple components as software for isocenter placement, movable external lasers, respiratory gating solutions for 4DCT or breath-hold acquisition and possibly Optical Surface Management Systems (OSMS) for a visually assisted patient positioning. The CT-scanner is dedicated on hardware and software level by means of a flat and geometrically accurate couch, a large bore, an extended Field of View (FOV), reliable conversion between Hounsfield Units and densities and the need for safe and seamless integration with the additional components. For proton therapy-planning Dual Energy CT (DECT) acquisition is needed, while for photon/electron RT and brachytherapy the clinical advantages of DECT are under investment. Potential applications of DECT are: metal artefact reduction, normal tissue characterization, improved dose calculation, and functional imaging for target localization [1,2]. On the other hand, specific cardiac gated procedures or CT-angiography are not applicable to CT-scanners for simulation. Vendors are moving towards a dedicated CT-simulator segment in their portfolio.

Dose optimisation has an increasing role in CT-simulation, which translates into a three level optimisation of *Dose-Contrast-Image Quality* [3, 4]. In case tube voltage optimisation is allowed in this process, electron density information needs to be provided to the Treatment Planning System (TPS). As RT is evolving towards adaptive treatment, multiple scans are needed throughout the course of a patient. Exposure due to CT-simulation together with Image Guidance for patient positioning (at the level of the treatment unit) adds upon radiation dose to healthy tissue of the patient. Calls have been made to implement an equivalent concept of Diagnostic Reference Levels 'DRL', for medical exposure during therapy [5, 6]. Multicentre dose registration and analysis could lead to this. This task probably is within reach, given the existing and well-performing radiation dose management platforms (e.g. TQM Dose- QAELUM, DoseWatch – GE, or others) for diagnostic CT-scanners.

These factors contribute to a situation where, while focusing on CT scanners, existing recommendations on diagnostic CT-scanners, even for state-of-the art multi-energy CT-scanner [7-9] are applicable to some extent on CT simulators but do not cover the entire simulation-process. Guidelines on respiratory motion in Radiation Oncology [10,11] also include 4DCT imaging during CT-simulation.

In 1997 NCS published guidelines for QA of Simulators and CT scanners [12] and partially updated the protocol by report NCS15 on QA of a 3D TPS [13]. Recent guidelines, specifically addressing CT simulation exist [14, 15] but only partially include recommendations on 4DCT or OSMS.

It is my belief that with this NCS subcommittee an opportunity can be taken to tackle these issues and formulate recommendations useful for the Radiotherapy community.

Provocative questions

Besides CT-simulation for photon/electron therapy and brachytherapy, will this report also include CT-simulation dedicated for proton therapy?

Including dual energy application in CT-simulation, will this report address clinical added value for CT-simulation for DECT ?

The main component of surface guidance systems is located at the treatment unit (e.g. linac). However, surface guidance imaging is increasingly used on CT-simulators, to setup reference situations for patient positioning or breathing/breath-hold patterns. Will this report address surface guidance systems at the level of CT-simulators ?

Will this report introduce a new concept equivalent to DRL, such as for instance MET-RL (Reference Levels for Medical Exposures during Therapy) ?

Draft-list for topics to be discussed

This list and its structure is to be debated

- Literature search on existing protocols
- Questionnaire to Belgian and Dutch RT departments on the equipment for CT-simulation currently in use.
- QA of CT-scanner itself for CT-simulation
    - Specific requirements (e.g. on table movement, on lasers)
    - Commissioning
- Dose-contrast-IQ optimisation
    - Dose: possibilities by Iterative reconstruction, by automated tube current and/or tube voltage modulation
    - Contrast:
        - use of patient specific Iodine volumes, iodine concentration as function of used tube voltage
        - use of dual energy (specific scan protocols to achieve optimal performance), applicability of Virtual Non-Contrast image sets (VNC)
    - IQ optimisation: contrast enhancement study, phantom spatial resolution information
    - How to set up a dose-contrast-IQ optimisation round or management system
- Reference Levels for CT-simulation
    - automated dose and contrast registration
- Simulation process accuracy and requirements
- Accuracy of CT-numbers
    - after metal artefact reduction
    - with tube voltage optimisation (e.g. on direct density images)
- 4DCT imaging: QA and how to implement
- Surface guidance at the level of CT-simulation

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