A proposed protocol for acceptance and constancy control of computed tomography systems

A Nordic Association for Clinical Physics (NACP) work group presentation

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Purpose with the work group

• Propose a comprehensive and standardized test regime for acceptance testing and annual QA of diagnostic CT systems

• This presentation will focus on the background and work methodology
Roles and Responsibilities of Medical Physicists

• International Organization for Medical Physics (IOMP):
  • Establishment, implementation, and supervision of radiation protection and safety programs
  • Measurement of radiation
  • Establishment, implementation, and supervision of quality assurance programs
  • Optimization of physical aspects of diagnostic and therapeutic procedures
  • Commissioning and supervising the delivery of complex or new clinical procedures
  • Technical specification of equipment and design of installations
  • Acceptance and commissioning of equipment
  • Technical supervision of maintenance
  • Research and teaching
Acceptance and constancy tests

- Essential part of the quality assurance (QA) regime
- Required in international standards
- Legislation in the Nordic countries for parameters influencing
  - Image quality
  - Radiation dose
Specification of QA tests for digital radiology modalities

- **Finland**
  - Radiation and Nuclear Safety Authority of Finland (STUK), 2006/2008
  - Covers all main X-ray modalities, including CT
  - Tests, methods and tolerance levels are specified

- **Sweden**
  - Swedish Radiation Safety Authority (SSM), 2009
  - Covers all main X-ray modalities, including CT
  - Tests are specified, but not methods and tolerance levels

- **Denmark**
  - National Institute of Radiation Protection (SIS), 1998
  - Covers all main X-ray modalities, including CT
  - Tests are specified, but not methods and tolerance levels

- **Norway**
  - The Norwegian Radiation Protection Authority (NRPA), 2010
  - No detailed specifications
Quality assurance for computed-tomography simulators and the computed-tomography-simulation process: Report of the AAPM Radiation Therapy Committee Task Group No. 66

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This document presents recommendations (AAPM) for quality assurance of computed tomography simulators. It was prepared by Task Group No. 66, a subcommittee of the AAPM Radiation Therapy Committee, with the aim of providing a comprehensive guide for the quality assurance of computed tomography simulators.

AAPM REPORT NO. 74
QUALITY CONTROL IN DIAGNOSTIC RADIOLOGY

NORDISK RAPPORTSERIE OM STRÅLSKYDDSSTRÄGOR
REPORT ON NORDIC RADIATION PROTECTION CO-OPERATION

No. 7
A Quality Control Programme for Radiodiagnostics Equipment:
Acceptance tests

The radiation protection and nuclear safety authorities in
Denmark, Finland, Iceland, Norway and Sweden

States: Institut for Strålehygiejn
National Institute of Radiation Hygiene
Knapsen 7
DK-2730 Herlev
Denmark

1999
What is the problem?

- Locally developed QA routines in each hospital region
- Standardization of the QA practices would be beneficial
  - Comparative QA data between countries and hospitals
  - Quickly growing data set covering many different CT system
  - Ease work for physicists working at smaller hospitals
A possible solution

• Nordic Association for Clinical Physics (NACP) initiative
  • Work group was formed
  • Medical physicists from all the Nordic countries (except Iceland).

• Aim
  • Discuss existing CT QA procedures
  • Propose a standardized Nordic recommendation for acceptance and constancy QA of CT systems.
Members and contributors

- **Finland**
  - Mika Kortesniemi
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  - Samuel Kuttner
Methodology 1

- First meeting during CT-course in Århus, November 2010

- 11 meetings during one year
  - Telephone meetings (free service from Telenor)
  - Live meeting during NACP Symposium in Uppsala in April 2011

- A secretary was picked for each meeting
  - Notes are good for future reference, and when someone cannot attend
Methodology 2

- Each member reported test details into a ”QA-table” within the following categories:
  - Gantry
  - X-ray tube
  - Image Quality

- Discussed each test separately and agreed on a recommendation

- Converted the recommendations into text, started on the article

[Image of medical equipment]
# Example of the QA-table

<table>
<thead>
<tr>
<th>Test</th>
<th>Purpose</th>
<th>Equipment</th>
<th>Measured parameter</th>
<th>Tolerance</th>
<th>Measured at acceptance?</th>
<th>Frequency of subsequent tests</th>
<th>Test performer</th>
<th>Reference</th>
<th>Hospital</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To assure the proper radiation beam collimation by measuring the dose sensitivity profile</td>
<td>Gafchromic film / wrapped CR plate / wrapped film / solid-state detector</td>
<td>mm (FWHM)</td>
<td>Not markedly wider than beam collimation</td>
<td>Yes</td>
<td>on acceptance</td>
<td>Maintenance / Physician / Engineer</td>
<td>National Authority guidelines (based on IPEM, etc.)</td>
<td>HUS</td>
<td></td>
</tr>
<tr>
<td>Dose profiles in Z-direction</td>
<td>Check the agreement between measured and specified dose profiles</td>
<td>Gafchromic film</td>
<td>FWHM of irradiated optical density profile on gafchromic film</td>
<td>Acceptance: Specified by vendor (~±20-30%) Constancy: Baseline ± 20% or 1 mm</td>
<td>Yes</td>
<td>Annually</td>
<td>Physicist</td>
<td>IPEM report 32, part III (2005)</td>
<td>Tromsø</td>
<td>Only axial scans, should we test helical here? <strong>ALSO GE BELOW</strong>!</td>
</tr>
<tr>
<td></td>
<td>To check and characterize the amount of overbeaming</td>
<td>Doseprobe, Barracuda with Dose Profile Analyzer</td>
<td>FWHM of dose profile, Geometric efficiency</td>
<td>Irradiated slice thickness (FWHM of the dose profile): Baseline +/- 20 % or +/- 1mm whichever is larger. Geometric efficiency &gt; 70% at all collimation settings</td>
<td>Yes</td>
<td>-</td>
<td>Physicist</td>
<td>Karolinska</td>
<td>Do you know how the dose profiler calculates GE? IEC has a &quot;new&quot; definition (2002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check over beaming properties of different collimations and study the tails of the LiC, FWT electrometer and special positioning system</td>
<td></td>
<td></td>
<td>Compare to last measurement</td>
<td>Yes</td>
<td>Annually</td>
<td>Physicist</td>
<td>System developed by me</td>
<td>NLL (SE)</td>
<td>Image 4 below</td>
</tr>
</tbody>
</table>
12. Dose profile in the Z-direction

**Purpose**
Check the agreement between measured and specified dose profiles.

**Equipment**
Radiographic/radio-chromic film, wrapped computed radiography plate, solid-state detector or other suitable measuring system.

**Outline of test method**
Irradiate the detector in air using scanner settings for Z-dose profiles given in the accompanying documents. Measurements from analog detectors should be digitalized and pixel values from any measurements should be converted to dose. Measure the FWHM of each dose profile and calculate the deviation from the specified values in the accompanying documents.

**Measured parameter**
FWHM of the dose profile.

**Remedial level**
Within vendor specifications, if available.

**Suspension level**

**Frequency**
A

**Reference**
(21)
## Considered tests

### Table & Gantry
- Patient table movement
- Zero degree gantry tilt
- Gantry tilt indicator
- Visual inspection of positioning lights
- Positioning lights
- Couch position and slice location

### Positioning system
- Dose display and specifications
- Dose free in air
- Dose-mAs linearity
- High voltage
- Half value layer (HVL)
- Dose profile in the Z-direction
- Geometric efficiency (GE)

### X-ray tube
- CT number of water
- CT number of various materials
- CT number linearity
- Tomographic section thickness
- Noise
- Uniformity
- Interslice noise
- Geometric accuracy
- Spatial resolution
- Low contrast detectability

### Optional tests
Current and future work

• Final adjustments to the report
• Implement protocol
• Data stored in a database
• Radiotherapy dedicated CT simulators
• New technology and future standards
  • Dosimetry
  • Dual energy
  • Dose reduction techniques
Conclusion 1

• Comprehensive test regime for acceptance and constancy tests for diagnostic CT scanners was developed, based on:
  • International guidelines
  • Authors’ practical experiences
• Final report may serve as a reference for medical physicists in the Nordic countries
• Total time: 1-1.5 years
Conclusion 2

• Advantegous work form
  • International work groups
  • Telephone conferences

• Requirements
  • ”Leader” who controls the work flow and delegates tasks
  • Motivated members in the work group
  • Time
  • Secretary who take notes during the meetings
  • Accept that not all members can meet every time
Conclusion 3

• Someone has to take the initiative and devote time for this important work

• NACP?
  • Digital radiography
  • Mammography
  • Workstation monitors
  • MR
  • Protocol optimization

• What’s in it for me?
  • We will get a unified Nordic community of standardized routines, procedures and protocols which may lead the way in the international radiology and physicist community
Thank you for your attention!
References


