Justification and optimisation of CT within a scientific framework

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Work in cooperation with
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Justification and optimisation of CT within a scientific framework

Spatial resolution

Balancing dose and image quality

Radiation risk assessment

Justification of practices

Spatial resolution: Imaging of the cochlear implant

Imaging of the cochlear implant

Selective shielding

Radiation risk assessment

Justification of practices

Guideline development

Spatial resolution: Imaging of the cochlear implant

Multislice CT (≥ 4 slice) since 1998

CT became a real 3D imaging modality

Z-axis

4-slice 1998

16-slice 2001

64-slice 2004

Submillimeter isotropic imaging

We want to image the cochlear implant and the surrounding bony structures

We want to measure the position of the electrodes relative to the bony structures
Spatial resolution: Imaging of the cochlear implant

64 slice scanners
GE Philips Siemens Toshiba
Lightspeed Brillance Sensation Aquilion

Smallest focal spot size (mm)
0.6 x 0.7 0.5 x 1.0 0.7 x 0.7 0.9 x 0.8

Acquisition configuration: active channels x detector size @ COR
64 x 0.625 64 x 0.625 2 x 32 x 0.6 64 x 0.5

In-plane spatial resolution (MTF0, lp/cm, mm/lp) sharpest algorithm
15.4 lp/cm 24 lp/cm 30 lp/cm 21.4 lp/cm
0.65 mm/lp 0.42 mm/lp 0.33 mm/lp 0.47 mm/lp

If the object consists of two ideal points, just a distance FWHM apart, there is a fair chance that they will be separated in the image.

Cochlear Implants
postoperative imaging: multi-slice CT (MSCT)

Cochlear implant:
Electrode size 0.4 mm!

fresh temporal bone (ex-vivo)
Balancing dose and image quality: Selective shielding

Absorbed dose to superficial organs and tissues was reported to be reduced by applying a sheet consisting of a compound of latex and bismuth on the skin close to superficial organs and tissues.

Heaney DE, Norvill CA. A comparison of reduction in CT dose through the use of gantry angulations or bismuth shields.


McLaughlin, D. J. and Mooney, R. B. Dose Reduction to Radiosensitive Tissues in CT. Do Commercially Available Shields Meet the Users' Needs?


Hopper, K. D. Orbital, Thyroid, and Breast Superficial Radiation Shielding for Patients Undergoing Diagnostic CT.


Can we trust this?
Balancing dose and image quality: Selective shielding

- Segmentation of soft tissue (WW100, WL20).
- Erosion of segmented soft tissue using a disk shaped structuring element.
- Noise (SD of HU) in ROI’s (8x8 pixels) entirely located within segmented regions.

Balancing dose and image quality: Selective shielding

Spatial resolution
Imaging of the cochlear implant
Radiation risk Assessment
Fatal tumor induction
Justification of practices
Guideline development

Radiation risk assessment: Fatal tumor induction

Risk of cancer – The Lancet

Although CT examinations make up only a relatively small part of the total number of x-ray examinations, CT contributes a high proportion of the collective effective dose. The figures shown refer to Germany for the year 2003 [BMU, 2003], but can be taken as largely representative for most western countries.
Radiation risk assessment: Fatal tumor induction

### Estimated number of radiation-induced cases of cancer per year in the UK by type of X-ray

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<thead>
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<th>X-ray Type</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
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<td>10</td>
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<td>15</td>
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<td>13</td>
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#### CT scan: highest estimated number of radiation-induced cases of cancer

Can we trust this?

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#### CT scan: highest estimated number of radiation-induced cases of cancer

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### Radiation risk assessment: Fatal tumor induction

**EVAR** (endovascular aneurysm repair): a new technology designed to treat AAA (abdominal aortic aneurysm)

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<th>Hospital</th>
<th>Cumulative effective dose after 5 year follow-up</th>
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<tr>
<td>A</td>
<td>130 mSv</td>
</tr>
<tr>
<td>B</td>
<td>160 mSv</td>
</tr>
<tr>
<td>C</td>
<td>210 mSv</td>
</tr>
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</table>

(pro-operate, per-operative and follow-up x-ray exposures (radiography, fluoroscopy and CT))

### Radiation risk assessment: Fatal tumor induction

Effective dose accumulates rapidly: a common scenario

- First year: 100 mSv
- Second year: 25 mSv
- Next years: 20 mSv per year

Disease related extra annual mortality

Three scenarios for the annual ERR:

- 0.00 no extra mortality
- 0.05 modest extra mortality
- 0.10 considerable extra mortality

Radiation risk model: BEIR VII
Radiation risk assessment: Fatal tumor induction

Survival curves
50 year old patient
EVAR for treatment of AAA
no ERR vs modest ERR
pre & per-operative exposures and follow up exposures

The Lancet, 2004

Realistic calculation

ERR = excess relative risk

Life expectancy (years)

<table>
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<tr>
<th>Health status</th>
<th>No ERR</th>
<th>Modest ERR (0.05)</th>
<th>Substantial ERR (0.1)</th>
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</thead>
<tbody>
<tr>
<td>Radiation risk</td>
<td>without / with</td>
<td>without / with</td>
<td>without / with</td>
</tr>
<tr>
<td>50 YOM</td>
<td>27.25 / 27.07</td>
<td>14.12 / 14.07</td>
<td>8.85 / 8.84</td>
</tr>
<tr>
<td>50 YOF</td>
<td>32.06 / 31.77</td>
<td>15.30 / 15.24</td>
<td>9.21 / 9.20</td>
</tr>
<tr>
<td>70 YOM</td>
<td>11.71 / 11.67</td>
<td>8.22 / 8.20</td>
<td>6.16 / 6.15</td>
</tr>
<tr>
<td>70 YOF</td>
<td>15.14 / 15.08</td>
<td>9.97 / 9.94</td>
<td>7.14 / 7.13</td>
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ERR: (annual) excess relative risk
Radiation risk calculated with the BEIR VII model
Radiation risk calculated for the following scenario: first year: 100 mSv; second year: 25 mSv; next years: 20 mSv per year

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Justification and practices: Guideline development

Justification of medical radiation exposure is clearly of value where there is a need to balance the risk of adverse consequences from exposure to ionising radiation with the risk of adverse events if the procedure is not performed. Case by case justification might also have a legitimate role in some optimisation exercises (SRP International Committee Working Party Summary Report).

How? Just ask the medical doctors (radiologist)?

Can we trust this?

Justification of practices: Guideline development

When is it justified to use CT?
A mathematical model for guideline development (Ying-Lie O; Leiden University Medical Center)
• Diagnostic imaging as an important technique for medical diagnosis
• Pros and cons of different scenarios (including radiation detriment)
• Complex interrelationships between disease and diagnostic techniques
• Evidence-based
Acute abdominal pain: many differential diagnoses:

- Appendicitis
- Peritonitis
- Ureteral inflammation
- Other diseases of the ureter
- Intestinal inflammation
- Other intestinal diseases
- Pancreatitis
- Gynaecological diseases
- …
Justification of practices: Guideline development