Building optimisation into routine practice

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Factors affecting dose and image quality in digital imaging

The clinical value of images is dependent on physical characteristics of the imaging method (~medical physicist), image capture and presentation system (~radiographer) and the interpreter (~radiologist).

### 1 Patient
- anatomy
- physiology
- target region

### 2 Imaging geometry
- focus-detector distance
- object-detector distance
- geometric distortion

### 3 Imaging parameters
- kVp, mA, s, focus
- filtering, collimation, grid
- dose

### 4 Movement
- patient
- x-ray tube

### 5 Detector
- pixel size
- number of pixels
- detector sensitivity (~DQE)

### 6 Post-processing
- def. pixel compensation
- uniformity correction
- target detection
- LUT transform

### 7 Image review
- ambient illumination
- surface reflections
- display performance

### 8 Image reviewer
- REPORT
- REFERRAL
The whole imaging chain and process must be evaluated.
Components and levels required for continuously improving optimisation

Within each component, levels of achieved performance will vary in different organisations.
Radiological professionals working together

C. Basic: Radiologists, radiographers, and medical physicists perform roles separately and independently of each other.

Establishing Diagnostic Reference Levels (DRLs) is involved in move from level C to B.

B. Intermediate: Optimisation Teams comprising radiographers, radiologists, and medical physicists established.

Comparison of dose survey results with DRLs, followed by review and optimise protocols for some modalities

A. Advanced: The whole Optimisation Team is involved in regular review of clinical protocols for all modalities.
Example of dose monitoring annual cycle plan
Comparing patient doses vs DRLs

- Abdomen + local Indication (trauma)
- Head + local Indication (perfusion)
- Chest + local Indication (cardiac)

2021
2022
2023
Ongoing
It’s not just about primary diagnostics. Differential diagnostics and incidental findings matter as well.
Successful operation of digital x-ray equipment requires high levels of knowledge and skill from clinicians, radiographers and medical physicists.

Settings should be agreed by members of the multi-professional imaging team and documented in protocols.

All members of the team must be given the necessary expertise through training and experience.

Training must be updated regularly, so everyone fully understands equipment operation.
Take full advantage of user training
It’s not just a system – require also the functionality and optimised protocols
Qualifiers of successful optimisation

• Ongoing, forward-looking, iterative process ⇒ continuous improvements with quantitative and qualitative evaluation.

• Systematic and carefully structured to ensure that all relevant aspects in the diagnostic chain are taken into account.

• Requires commitment at all levels as well as adequate procedures and resources in organisations.

• Optimisation is not minimisation of dose – it’s a question of balance; the best option is not necessarily the one with the lowest dose.
Two levels of optimisation

Regular review of every aspect of the imaging process is key to the successful achievement of optimisation.

1) The design and construction of the equipment and the installation
2) The day-to-day working procedures performed by the staff involved

Optimisation will only occur if:
1) All staff are properly trained in their roles
2) Equipment operation is ensured through a comprehensive QA programme
3) There is ongoing monitoring, review, and analysis of performance
4) This feeds back into continual improvement of protocols.
Practical multiprofessional optimisation during commissioning

- C: Set the basic parameters
- B: Adjust indication specific parameters to maximise image quality per dose unit (e.g. spectral optimisation)
- A: Adjust patient-specific parameters (typically mAs by ATCM) in individual exams to achieve diagnostic image quality with the lowest dose
- Harmonise protocols (incl. exposure parameters) in order to achieve consistent image quality throughout the organisation
Clinical image quality ⇔ Determination of indication specific target values

Radiologist

Feedback on clinical image quality

Optimisation adjustments and patient doses

Conformance evaluation and tech optimisation

Functional status and service reporting

Radiographer

Feedback on clinical image quality

Workflow optimisation and patient safety issues

Malfunctions and deviations

Functional status and service reporting

Service

Communication!

Physicist

QA co-ordination and follow-up
Technical QC tests and dose evaluations
⇒ Conformance of vendor specifications, standard and legislative requirements and tolerances, specific target values

Conformance evaluation and tech optimisation

Mechanical & safety tests
Technical phantom scan
Basic dose measurement
⇒ Conformance of vendor specifications

Multiprofessional collaboration
Main directions of developing methods

Consistency

reducing variability

Quality

on average
Main directions of developing methods

- **Reducing variability**
- **Clinical relevance**
- **Consistency**
- **Quality on average**
- **Technical performance**
Utilising anthropomorphic models in optimisation
⇒ Aiming closer to clinical cases
### Example of anatomical & indication based DRLs
(for CT in Finland)

<table>
<thead>
<tr>
<th>Examination type or indication</th>
<th>CTDI$_{\text{vol}}$ (mGy)</th>
<th>DLP (mGy·cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head/brain</td>
<td>55</td>
<td>800</td>
</tr>
<tr>
<td>Sinuses</td>
<td>13</td>
<td>190</td>
</tr>
<tr>
<td>Chest</td>
<td>9</td>
<td>290</td>
</tr>
<tr>
<td>Abdomen</td>
<td>12</td>
<td>560</td>
</tr>
<tr>
<td>Body</td>
<td>12</td>
<td>770</td>
</tr>
<tr>
<td>Aorta (neck to groin)</td>
<td>10</td>
<td>630</td>
</tr>
<tr>
<td>Indication - HRCT</td>
<td>5</td>
<td>140</td>
</tr>
<tr>
<td>Indication - lung tumour</td>
<td>11</td>
<td>430</td>
</tr>
<tr>
<td>Indication - renal stones</td>
<td>7</td>
<td>330</td>
</tr>
<tr>
<td>Indication - lymphoma</td>
<td>11</td>
<td>970</td>
</tr>
<tr>
<td>Indication - trauma body</td>
<td>17</td>
<td>1300</td>
</tr>
<tr>
<td>Indication - colonoscopy (prone)</td>
<td>6.5</td>
<td>total from both positions: 930</td>
</tr>
<tr>
<td>Indication - colonoscopy (supine)</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
Towards patient-specific dosimetry – example: CT

- More effective optimisation
- Exposure monitoring and dose registry systems
- Radiation safety research

- Patient specific organ doses and effective doses
- Anthropomorphic organ doses
- Patient size specific local dose units (SSDE(z))
- Patient size specific global dose units (SSDE)
- Modality specific dose units (CTDvol, DLP)

Basic technical dose output measurements & dose data

MC & DL methods

Anthropomorphic phantoms & experimental verification
Gradual unification of core RP components by evolving methods and processes

- **Patient Specific Parameters with Clinical Focus**
- **Quality Assurance**
- **Optimisation**
- **Justification**

- **Wide Scale On-line Data Access & Monitoring**
- **Harmonized Imaging Parameters & Protocol Rules**

Evolved QA methods enable more effective patient-specific optimisation with clinical relevance.

Automated referral guidance and procolling connect optimisation and justification more closely together.
Formal policy - mission, vision and strategy, systems and practices

Informal practices and **culture**

**Beliefs, values and attitudes**

**Culture eats strategy for lunch every day.**
When you aim for improvements by planning and doing, also check the outcome systematically to reach effective outcome.

“What if we don’t change at all ... and something magical just happens?”
Importance of continual improvement

Phantoms
QA programme
Dose audits
DRLs
Regular IQ evaluation
Dose monitoring system

Resources
Roles
Training
Processes
Documentation

Data safety & security

CONTINUOUS IMPROVEMENT

PLAN
DO
ACT
CHECK

ICRP
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Thank you for your attention

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