TG 108: Equipment Life Cycle & Patient Dosimetry

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Optimisation

Optimisation is hard to pin down - but is the key to protection.

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

Major Factors
The design, specification and installation of the equipment
The day-to-day working procedures performed by the staff involved

Optimisation most likely if:
1) Radiologists, radiographers, and medical physicists work together
2) All staff are properly trained in their roles
3) Equipment operation is assured through a comprehensive QA programme
4) There is ongoing monitoring, review, and analysis of performance that feeds back into continual development of protocols.
Optimisation is a continual process and is inextricably bound up with the minutiae of the imaging equipment life cycle.

Each element of the life cycle contributes to successful optimisation and is discussed in the report.
The procurement of all medical imaging equipment needs to be justified, both in terms of clinical need and radiation dose.

Justification should be evidence driven and take into account present and future clinical applications and revisions of workflow whilst ensuring that there is no unnecessary proliferation of equipment.
Optimisation:

Life Cycle

- Justification
- Acquisition
- Installation
- Acceptance and Commissioning
- User Training
- Clinical Use
- Disposal

- It is essential that a full performance specification of the entire system is established before any purchases are made.

- The performance specification should include consideration of the intended clinical use of the equipment and also technical requirements relating to patient dose and image quality.
Optimisation

Life Cycle

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- Planning and construction of the x-ray room, protection, electrical and other services all need to be prepared beforehand, and consideration given to facilitating the appropriate movement of the patient and positioning of the attending staff.
Optimisation

Life Cycle

- Justification
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- Installation
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- The purchaser needs to satisfy themselves that the equipment supplier has provided what has been ordered.
- They also need to ensure that the equipment is ready for clinical use and establish baseline values against which the results of subsequent routine performance tests can be made.
Optimisation

Life Cycle
- Justification
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- User Training
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- Disposal

- User training on new equipment is a crucial stage in optimisation
Optimisation

Life Cycle

- Justification
- Acquisition
- Installation
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- Clinical Use
- Disposal

- Regular review of protocols taking account of dose and imaging performance are key to achieving optimisation
Optimisation is a continual process and is inextricably bound up with the minutiae of the imaging equipment life cycle.

Each element of the life cycle contributes to successful optimisation.
NB Perceived Image Quality is Task & Reader Dependent
Optimisation

Patient Doses - Aspects discussed in the report

- The influence of exposure factors on radiological images
- Surveys and audit of patient dose data
- Measurement & retrieval of patient dose data
- Analysis and feedback of patient dose data
- The outcome of the audit process
- Patient radiation exposure monitoring / management systems
# Equipment factors affecting patient dose & image quality

<table>
<thead>
<tr>
<th>Factor (single factorial)</th>
<th>Effect on Patient Dose (to maintain same Air Kerma at detector)</th>
<th>Image Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase field size</td>
<td>Increased $P_{KA}$; $K_{a,e}$ constant</td>
<td>Increase scatter</td>
</tr>
<tr>
<td>Introduce anti scatter grid</td>
<td>Increased $P_{KA}$; $K_{a,e}$ increased</td>
<td>Decrease Scatter</td>
</tr>
<tr>
<td>Increase beam filtration</td>
<td>$P_{KA}$ reduced; $K_{a,e}$ reduced</td>
<td>Reduce Contrast</td>
</tr>
<tr>
<td>Increase FID</td>
<td>None</td>
<td>Reduce unsharpness</td>
</tr>
<tr>
<td>Increase focal spot size</td>
<td>None</td>
<td>Increase unsharpness</td>
</tr>
<tr>
<td>Increase anode angle</td>
<td>None</td>
<td>Increase unsharpness, (increase useful FOV)</td>
</tr>
<tr>
<td>Decrease patient to detector distance</td>
<td>$P_{KA}$ reduced; $K_{a,e}$ reduced*</td>
<td>Decrease unsharpness, but increase scatter at detector</td>
</tr>
</tbody>
</table>
Methodology: Dose Audit – an important step in the optimisation process

Knowledge of the doses delivered to patients is one of the first steps in the clinical optimisation process and personnel involved in performing the exams should have ownership or involvement in the process of dose audit.

A multi-disciplinary team approach helps to ensure that results of dose surveys are fed back to operators who make changes that are needed.
Diagnostic Reference Levels

- Based on the premise that if most radiologists agree that a particular dose produces an image that is diagnostic then it probably is diagnostic.
- A blunt tool that acts as a guide guide to the – indistinct – border between good / normal practice and bad / abnormal practice.
- Just a step on the road to optimisation.

Task dependence. What colour are her eyes?
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<tr>
<th>Level</th>
<th>Description</th>
<th>Details</th>
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</table>
| D: Pre-optimisation level (Basic infrastructure) | • Availability of radiation instruments for measurement of radiation dose and exposure parameters  
• Availability of simple protocols setting out measure equipment performance.  
• Purchase of range of instruments sufficient for carrying out QC tests on all imaging modalities.  
• X-ray equipment has displays of dose parameters (e.g. KAP for radiography and fluoroscopy and displays of CTDI_{vol} and DLP on CT scanners) | |
| C: Basic (Level D plus) | • Calibration of all KAP meters, and displays of CTDI_{vol} and DLP  
• Dose audits performed every 3 years  
• Dose audit results fed back to radiographers and radiologists periodically  
• In process of developing national DRLs | |
| B: Intermediate (Levels D and C plus) | • Standardisation of protocol names for procedures  
• Radiologists have agreed arrangement for development of examination protocols  
• Agreed codes for identifying more complex examinations  
• National DRLs established for a wide range of procedures  
• Annual survey of patient doses on wide range of procedures  
• Local DRLs and typical values set by organisation linked to local dose surveys  
• Results of patient dose audit included in annual review of examination protocols | |
| A: Advanced (Levels D, C and B plus) | • Continual feedback and comparison of patient dose results with typical values  
• Application of dose management system software  
• Comparison of CTDI_{vol} values with other results at time of CT examinations  
• Alignment of protocols for standard indications throughout organisation |
Including Dose in an Optimisation Strategy – Level C

**PROFESSIONALISM**
- Separate Roles for staff groups

**METHODOLOGY**
- Use of task related metrics
- Comprehensive testing for dose and image quality
- Basic dose performance testing

** PROCESSES**
- Systems applied across organisation
- Harmonised activities, systematic documentation, dose audit with DRLs
- Isolated site-specific activities and sporadic documentation

**Pre-optimisation level, setting of basic infrastructures**

**Towards multi-professional approach**
- Multi-professional teams
- Versatile joint tasks and responsibilities
- Rigid professional roles and traditional organisational hierarchy
<table>
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<tr>
<th>Quality Management</th>
<th>Quality Assurance</th>
<th>Quality Control</th>
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<tbody>
<tr>
<td>Management of processes with:</td>
<td>Planned and systematic procedures for:</td>
<td>Planned and systematic procedures for:</td>
</tr>
<tr>
<td>• Improved clinical outcome</td>
<td>• Clinical image quality evaluation</td>
<td>• Technical equipment performance tests including technical image quality tests and radiation output tests</td>
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<tr>
<td>• Continual improvement of quality and safety [Plan-Do-Check-Act cycle (PDCA)]</td>
<td>• Patient dose surveys and comparisons with DRLs</td>
<td>• Radiation safety tests</td>
</tr>
<tr>
<td>• Reviewing established quality criteria and policy</td>
<td>• Image reject and retake analysis</td>
<td>• Technical safety tests</td>
</tr>
<tr>
<td>• Ensuring adequate resources</td>
<td>• Equipment maintenance and life cycle (incl. acceptance and commissioning)</td>
<td>• QC and QA documentation</td>
</tr>
<tr>
<td>• Alignment with organisational purpose and strategy</td>
<td>• QC and QA documentation</td>
<td>• Test frequencies and tolerances</td>
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<tr>
<td>• Leadership commitment</td>
<td>• Test frequencies and tolerances</td>
<td>• Self-evaluations and audits</td>
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<tr>
<td>• Fostering no-blame culture</td>
<td>• Leadership commitment</td>
<td>• Staff roles and responsibilities</td>
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<td></td>
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<td>• Training and knowledge</td>
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<td>• Research and development aspects of quality</td>
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**Quality Management:**
- Management and set of quality processes focused on consistently meeting quality measurements.

**Quality Assurance:**
- Methods, equipment, and their clinical use.
- Full specified requirements and regulations.

**Quality Control:**
- Equipment performance conforms to specifications and regulations.
- Technical equipment performance tests including technical image quality tests and radiation output tests.
- Radiation safety tests.
- Technical safety tests.
Thank you for your attention