The Role of Key Professionals in Improving Patient Outcome through Technology Life Cycle Management – Medical Physicists

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Medical Physicist Functions (1)

- Develop / Review Equipment* Purchase Specifications
- Acceptance Testing
  - Agreement with Manufacturer’s Specifications
  - Setting Base Line Values for QC Tests
- Commissioning
  - Data Acquisition for Clinical Use

* Equipment = Hardware & Software!
Acceptance Testing and Commissioning – Radiation Therapy

▲ Non-dosimetric testing
  ❖ Image import, segmentation, densities
  ❖ Machine & beam characterization
  ❖ Plan evaluation, output, implementation

▲ Dose calculations
  ❖ Data measurement, entry
  ❖ External beam calculation verification
  ❖ Brachytherapy calculation verification
  ❖ Absolute dose, plan normalization

G. Ibbott 2007
Commission Radiological Equipment

Patient Protocols

- Adult
- Pediatric
Medical Physicist Functions (2)

- Calibrate Radiation Sources

**External Beam**

**Activity Meters**
(Dose Calibrators)

**Brachytherapy**
Medical Physicist Functions (3)

- Evaluate Medical Imaging Equipment
  - Performance
  - Image Quality

- Conventional and Digital Radiology
- Computed Tomography
- Ultrasound
- Magnetic Resonance Imaging
- Nuclear Medicine / Hybrids
  - Gamma Camera, SPECT, PET
  - PET/CT, SPECT/CT, MR/PET, MR/US
Image Quality Test

Using ACR Phantom
Simulating 4.2 cm Compressed Breast

Mammogram

Tolerances (mm)

- MASS
  - 0.25 - 2.00
  - 0.75

- SPECK
  - 0.16 - 0.4
  - 0.2

- FIBER
  - 0.40 - 1.56
  - 0.75
## CT image quality evaluation

<table>
<thead>
<tr>
<th></th>
<th>Old Era</th>
<th>New Era</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phantom</strong></td>
<td>complicated</td>
<td>basic</td>
</tr>
<tr>
<td><strong>Analysis</strong></td>
<td>simple</td>
<td>more sophisticated</td>
</tr>
<tr>
<td><strong>Results</strong></td>
<td>perfunctory</td>
<td>useful &amp; quantitative</td>
</tr>
</tbody>
</table>

**MTF (f)**

\[
MTF(f) = \frac{\int LSF(x) e^{2\pi ifx} \, dx}{\int |LSF(x)| \, dx}
\]
Medical Physicist Functions (4)

- Ensure interconnectivity & interoperability of networked equipment

**HIS / RIS / PACS**

- Acquisition Systems: (CT, MR etc)
- Portal Imaging
- Database
- Hard Copy (Printer, Camera)

Images → SS, Plan, Image → SS, Plan, Dose → All → Record

Simulator → Virtual Simulator → Treatment Planning System → Review Station → Linac
Medical Physicist Functions (5)

- Test / Calibrate Physics Equipment
- Electrometers & Ionization Chambers
- TLDs & TLD Reader
- OSL / Diodes & Readers
- Film (Silver Halide & Radiochromic)
- Densitometers / Scanners
- Gas-Filled Survey Meters
- Scintillation Detectors
- Gel-Based Dosimeters
Medical Physicist Functions (6)

- Participate in the Treatment Planning Process
  - Radiation Oncology
    - Physical / Virtual Simulation
  - Interventional Radiology
    - Navigational and Robotics Techniques
      - Conventional CT
      - Cone Beam CT
Medical Physicist Functions (7a)

- Perform / Supervise Clinical Dosimetry

In Radiology Departments:

▲ Establish Diagnostic Reference Levels
  - Conventional Radiography / Fluoroscopy
  - CR / DR
  - CT
  - Interventional Radiology (Analogical / Digital)
Medical Physicist Functions (7b)

- Perform / Supervise Clinical Dosimetry in Radiation Oncology Departments:

Software

Automatic Input
3-D Dose Distributions
Surface & Volume Rendering
Dose / Volume Histograms
Inverse Planning
Medical Physicist Functions (8)

- Supervise Patient Accessory Construction
  - Immobilizers
  - Masks
  - Blocks
  - Cut outs
  - Compensators
Medical Physicist Functions (9)

- Supervise Applicator / Catheter Preparation
  - Sources
  - Dummy Sources
  - Source Guides
  - Cables
  - Templates
Medical Physicist Functions (10)

- Supervise / Perform Dosimetry
- Accessory Construction
- Jig for Orthogonal Film Radiography
- Dosimetry Phantoms
  - Water, Plastic & Anatomical
- Autoradiography Jig / Phantom
- Source Holders for Well Type Ionization Chambers
- Thimble Ionization Chamber Holders / Supports
- Treatment Templates
Medical Physicist Functions (11)

- Verify Treatment / Supervise Radiotherapists
Chart Checking (Second Review)
(First Reviewer: Dosimetrist)
Evaluate Daily Dose Distributions

Verification Dose List:
- Plan_01 - Procedure 17 Sinogram performed at Sep 9, 2005, 8:25 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 16 Sinogram performed at Sep 9, 2005, 8:26 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 15 Sinogram performed at Sep 2, 2005, 7:46 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 14 Sinogram performed at Sep 1, 2005, 7:52 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 13 Sinogram performed at Aug 31, 2005, 7:45 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 12 Sinogram performed at Aug 30, 2005, 8:09 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 11 Sinogram performed at Aug 29, 2005, 7:49 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 10 Sinogram performed at Aug 26, 2005, 7:56 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 9 Sinogram performed at Aug 25, 2005, 8:15 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 8 Sinogram performed at Aug 24, 2005, 7:49 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 7 Sinogram performed at Aug 23, 2005, 7:49 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 6 Sinogram performed at Aug 22, 2005, 8:31 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 5 Sinogram performed at Aug 19, 2005, 8:32 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 4 Sinogram performed at Aug 18, 2005, 7:54 AM / Tomotom Rez acqu...
- Plan_01 - Procedure 3 Sinogram performed at Aug 17, 2005, 7:46 AM / Tomotom Rez acqu...

R. Mackie 2009
Medical Physicist Functions (12)

- Make In Vivo Patient Dosimetry Determinations

TLDs

Diodes
In Interventional Exams, Maximum Skin Dose Can Be Determined With Radiochromic Film

<table>
<thead>
<tr>
<th>Loc</th>
<th>Dose (Gy)</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>0.34</td>
</tr>
<tr>
<td>B</td>
<td>1.81</td>
</tr>
<tr>
<td>C</td>
<td>3.54</td>
</tr>
<tr>
<td>D</td>
<td>0.46</td>
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<tr>
<td>E</td>
<td>3.54</td>
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<tr>
<td>F</td>
<td>1.97</td>
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<tr>
<td>G</td>
<td>1.26</td>
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<td>H</td>
<td>0.65</td>
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<td>I</td>
<td>0.31</td>
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<tr>
<td>J</td>
<td>1.20</td>
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<tr>
<td>L</td>
<td>1.03</td>
</tr>
<tr>
<td>M</td>
<td>0.19</td>
</tr>
<tr>
<td>N</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Coronary Angioplasty
Quantificação em PET com \(^{(18\text{F})}\text{FDG}\)

**SUV**

*Standardized Uptake Values*

$$
SUV = \frac{\text{atividade \_média \_mililitros}}{\text{atividade \_total \_injetada \_mililitros}}
\quad \text{tecido}\over\text{corpo \_inteiro}
$$

$$
SUV_{massa} = \frac{\text{atividade \_média \_mililitros}}{\text{atividade \_total \_injetada \_mililitros}}
\quad \text{tecido}\over\text{massa \_do \_paciente (g)}
$$

Dificuldades na quantificação:

1. Correções e aquisição das imagens
2. Características próprias do paciente e da biodistribuição do radiofármaco.

L. Pozzo
Medical Physicist Functions (13)

- Supervise Maintenance Program
- Develop & Supervise QC Program
- Promote / Develop / Participate in Research

Micro PET / MR (Cambridge University)
Medical physicists also perform radiation safety functions.
Radiation Safety Functions (1)

▲ Prepare License for Regulatory Authority (RA)

▲ Review Floor Plans, Controlled & Supervised Areas

▲ Perform and/or Review Structural Shielding Calculations

High Energy Linac
Radiation Safety Functions (3)

▲ Verify
- Equipment Compliance with IEC Safety Features and/or Equivalent National Standards
- Radiation Warning Signs
- Door Interlocks
- Radiation Emergency Controls

▲ Perform Radiation Safety Surveys

▲ Establish
- Dose Constraints
- Operational Limits
Photograph of a Co-60 Source Change
Radiation Safety Functions (4)

- Document Staff and Consultants’ Qualifications
- Develop Radiation Safety QC Program
- Chair Radiation Safety Committee
- Impart Radiation Safety Training Courses
Radiation Safety Functions (5)

▲ Maintain Inventory of all Radioactive Sources

• Receipt, Use, Disposal

▲ Maintain up-to date license-related documents
▲ Keep up on staff changes & qualifications
▲ Liaise with the Regulatory Authorities
Medical Physics / Radiation Safety Functions

- Participate in QA Program
- Investigate Accidental Medical Exposures
- Participate in Accreditation Process