MEDICAL RADIATION PHYSICS TRAINING WITH EMERALD and EMIT e-LEARNING MATERIALS

EMERALD and EMIT Consortia

EU Leonardo Project: European Medical Radiation Learning Development - Internet Issue

- EuroConference on Medical Physics & Engineering Education - Budapest '94
- Book with Education & Training Programmes
- Inter-University Med. Phys. Centre, Plovdiv
- Joint Baltic MSc course (Tempus proj.)
- Project EMERALD (3 books and 3 CD)
- EuroConference on Medical Physics Training (26 countries) - Triest '98
- 6 Emerald Training Seminars in Europe
- EMERALD e-learning
- EMIT e-Learning

Assessment of the needs and feedback were pivotal for the development of these pilot projects
The delivery of contemporary healthcare is impossible without medical technology - one of the most advanced technologies of our time.

1. The biggest e-L advantage is the easy explanation of contemporary science. Adding computer simulations, interactive diagrams or just pictures increases enormously the effectiveness of teaching.

2. The easy upgrade of e-L materials is an advantage, imperative for dynamic profession as Medical Engineering and Medical Physics.

Quality Control based on EMERALD X-ray Diagnostic Radiology training

Dr Slavik Tabakov
EMERALD Consortium, King’s College London
Objective of Project EMERALD

Development of 3 common training modules in:
- Diagnostic Radiology Physics,
- Nuclear Medicine Physics,
- Radiotherapy Physics,

each with duration of 4 months

4 months condensed EMERALD training (international)
plus 1-2 months further in-house training (national)

EMERALD Structured Training Modules

Each module incorporates:
- List of Competencies
  (based on the IPEM scheme);
- Structured Timetables;
- Student Workbook with tasks;
- Teacher’s (Course) Guide
- CD-ROM with images
  (searchable database);
- EMERALD e-book with tasks
Student Workbook

Each Student Workbook contains:
- Structured Training Timetable,
- Tasks with detailed explanations tables, references and other data,
- Questions to be answered,
- Verification, etc.

National Introduction - Sep’97
Refereeing
International Introduction - Sep’98

TRAINING MODULE “PHYSICS OF DIAGNOSTIC RADIOLOGY”

TRAINING TIMETABLE

<table>
<thead>
<tr>
<th>No.</th>
<th>Sub-module</th>
<th>Competencies (*)</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction. Program. Using the training materials</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>General principles of Radiation Protection in DR</td>
<td>General</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>General principles of DR Quality Control organisation/ equipment</td>
<td>General</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>X-ray dosimetry and Patient dosimetry</td>
<td>3,5,9,10,12,13</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>Radiological image</td>
<td>3,7,10,11,14</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>X-ray tube and generator</td>
<td>2,3,4,5,14,15,22</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>Radiographic Equipment</td>
<td>1,2,3,4,5,6,8,10,14,16</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>X-ray screens/films and Laboratory</td>
<td>1,7,8,16</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Fluoroscopic Equipment</td>
<td>1,2,3,7,8,10,11,14,15,16</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>Digital Imaging and CT Equipment</td>
<td>1,2,6,7,8,10,14,16</td>
<td>10</td>
</tr>
<tr>
<td>ii</td>
<td>Basis of shielding in Diagnostic Radiology</td>
<td>16,17,18</td>
<td>5</td>
</tr>
<tr>
<td>iii</td>
<td>Organising of the portfolio, training assessment, etc.</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Total for 4 months: 16 weeks x 5 days = 80 days</td>
<td></td>
<td>80</td>
</tr>
</tbody>
</table>

Total: 80
<table>
<thead>
<tr>
<th>Sub-module and Subject</th>
<th>Necessary materials/arrangements</th>
<th>Competencies acquired</th>
<th>Days/Vs</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray tube and generator</td>
<td>X-ray tube diagrams; Different company brochures; Several types tube inserts</td>
<td>Understand/measure compare separate X-ray tube/gen. parameters <em>(2,3,4,5,14,15,22)</em></td>
<td>2</td>
</tr>
<tr>
<td>Basic X-ray tube Components and Characteristics.</td>
<td>X-ray tube diagrams; Different company brochures; X-ray tube inserts</td>
<td>Understand/compare X-ray tube parameters.</td>
<td>2</td>
</tr>
<tr>
<td>Assessment of X-ray tube Leakage radiation and X-ray tube output total filtration</td>
<td>Tube housing; X-ray radiogr. room; Dosemeter; Al plates HVL/Filt. diagrams; ~6 X-ray film/cassettes</td>
<td>Understand/measure X-ray tube filtration</td>
<td>1</td>
</tr>
<tr>
<td>Assessment of X-ray tube output parameters</td>
<td>X-ray radiogr. room; Dosemeter; calculator, Foc. spot meas. tool; LBBD align. tool</td>
<td>Understand/measure calculate tube output param., focal spot size and LBBD. Learn to season the tube</td>
<td>2</td>
</tr>
<tr>
<td>Assessment of X-ray Generator kVp and Timer parameters</td>
<td>X-ray gen. diagrams; X-ray radiogr. room; kVp divider; kVp non-inv. meter; oscilloscope; kVp cassette; mA and Timer meters.</td>
<td>Understand/measure kVp with different tools. Assess ripple. Measure mA, time of the exposure</td>
<td>2</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Sub-module and Subject</th>
<th>Necessary materials/arrangements</th>
<th>Competencies acquired</th>
<th>Days/Vs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiographic Equipment</td>
<td>Using and QC of radiographic equip. <em>(1,2,3,4,5,6,8,10,14,16)</em></td>
<td>Using QC equipment; Practical selecting X-ray parameters; Patient care.</td>
<td>12</td>
</tr>
<tr>
<td>Familiarisation with General Radiography Equipment.</td>
<td>General acquaintances with practice (patients) in the Radiographic room</td>
<td>Using QC equipment; Practical selecting X-ray parameters; Patient care.</td>
<td>2</td>
</tr>
<tr>
<td>Quality Control of a typical Radiography equipment.</td>
<td>X-ray radiogr. room; Dose; kVp, etc. meters; QC protocols, PC.</td>
<td>Perform QC tests and QC protocols; Accept DR radiogr.eq.</td>
<td>2</td>
</tr>
<tr>
<td>Quality Control of Mobile Radiography equipment (capacity discharge equipment).</td>
<td>Mobile X-ray radiogr. eq.; QC equipment; QC protocols, PC.</td>
<td>Perform specific QC tests and QC protocols for mobile radiogr. eq. Interpret QC result</td>
<td>1</td>
</tr>
<tr>
<td>Quality Control of Dental Radiography Equipment.</td>
<td>Dental X-ray radiogr. eq.; QC equipment; QC protocols, PC.</td>
<td>Perform specific QC tests and write QC protocols for Dental equipment.</td>
<td>2</td>
</tr>
<tr>
<td>Quality Control of Mammography Equipment.</td>
<td>Mammo X-ray radiogr. eq.; Special Mammo QC equip. and test objects; QC protocols, PC.</td>
<td>Perform specific QC tests and write QC protocols for Mammography equipment.</td>
<td>2</td>
</tr>
<tr>
<td>Assessment of Conventional Tomography Equipment</td>
<td>Tomogr. X-ray radiogr. eq.; QC equipment and test objects; QC protocols, PC.</td>
<td>Perform specific QC tests and write QC protocols for Tomographic equipment.</td>
<td>1</td>
</tr>
<tr>
<td>Assessment of Automatic Exposure Control (AEC) systems in Radiography.</td>
<td>X-ray AEC radiogr. eq.; QC equipment, test objects; QC protocols, PC.</td>
<td>Use of different AEC. Perform specific QC tests and write QC protocols for AEC.</td>
<td>2</td>
</tr>
</tbody>
</table>
5.2 ASSESSMENT OF X-RAY TUBE TOTAL FILTRATION

5.2.1 Task
Short explanation of the task; Approx. time for performing the task

5.2.2 Competencies Addressed
Understand and measure the X-ray tube beam filtration

5.2.3 Equipment and Materials
List with necessary Equipment, Materials, Arrangements

5.2.4 Procedures and Measurements
For Assessment of X-ray Tube Output Total Filtration
Detailed description of a method to perform the task

<table>
<thead>
<tr>
<th>Added Al (mm)</th>
<th>Set kV (~80)</th>
<th>Set mA</th>
<th>Set msec (~20-40)</th>
<th>Meas. exp (mGy)</th>
<th>Exp. decr. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+0mm Al</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>+1mm Al</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2mm Al</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+3mm Al</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+4mm Al</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td>&lt;50</td>
</tr>
</tbody>
</table>

5.2.5 Calculations
For Assessment of X-ray Tube Output Total Filtration
Detailed description of a method to calculate certain parameters

5.2.6 Observations, Interpretations, Conclusions
Questions to answer; Problems to think about; Conclusions

5.2.7 References
List of some relevant books, documents, etc.

Verification
Signature and date by the trainer:

Task Performance - Example 1 (2 days)

8.1 - Basic Fluoroscopic X-ray Equipment QC

8.1.3 Equipment and Materials
- Block diagrams of fluoroscopic X-ray equipment.
- Information and images from several types of image test objects.
- A set of image test objects (minimum: edge phantom, spatial resolution phantom, contrast resolution phantom - overall image quality phantom).
- Copper plate 1 mm thick and with surface about 150 x 150 mm.
- Dosimeter with flat ionisation chamber. Oscilloscope. Tape measure.
8.1.4 Procedures and Measurements

Familiarisation with Block Diagrams of Fluoroscopic X-ray Equipment

Study the block diagram of the Image Intensifier and identify it's parts.

Comment on different types of luminifors used in II.

Study the block diagram of the TV video camera and identify it's parts.

Comment on different types of TV camera tubes.

Study the concepts of II Conversion factor and Contrast ratio.

Familiarisation with Different Types of Image Test Objects

Study the images of several types of test objects.

Use the table given below (based on real measurements) to draw the contrast-detail characteristic:

[min. visible contrast] as a function of the [corresponding detail size]

<table>
<thead>
<tr>
<th>Row (for TO10)</th>
<th>Detail size diameter</th>
<th>Detail number and limiting contrast with II field size (using Leeds Test Object TO10 with ABC system on)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>II image field = 30cm</td>
<td>II image field = 23cm</td>
</tr>
<tr>
<td></td>
<td>80kV</td>
<td>0.2mA</td>
</tr>
<tr>
<td>A</td>
<td>11.1</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>7.9</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>5.6</td>
<td>6</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>E</td>
<td>2.8</td>
<td>5</td>
</tr>
<tr>
<td>F</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>G</td>
<td>1.4</td>
<td>4</td>
</tr>
<tr>
<td>H</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>J</td>
<td>0.7</td>
<td>2</td>
</tr>
<tr>
<td>K</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>L</td>
<td>0.35</td>
<td>0</td>
</tr>
<tr>
<td>M</td>
<td>0.25</td>
<td>0</td>
</tr>
</tbody>
</table>
Familiarisation with the Concepts of II Image Brightness and Contrast and with Video Signal Assessment.

Connect the oscilloscope to the signal from the II TV camera - either at the special output of TV monitor or with a T-junction BNC connector (remember to terminate the TV signal chain (normally with 75 ohm special terminator). Set the oscilloscope parameters to 0.2 V and 10 ms/per division (TV signal measurements).

Use X-ray beam with 1 mm Cu attenuation and place the Step-wedge phantom (in case of Leeds test objects - Gray scale TOGS) as close as possible to the II, observe the set contrast and brightness and mark the proper position of the TV monitor contrast and brightness.

Record again the maximal amplitude of the video signal and measure the II entrance dose rate for this new image.

Select the appropriate II entrance dose rate (according to the manuf. specifications) - normally this is in the region of 0.2 - 10 µGy/s.

Measure (at least for two II field sizes) the specific parts of the video signal, given on the figure, and record them in the table:
Results

8.1.5.1   Compare the characteristics of two TV camera tubes - Vidicon Plumbicon.
8.1.5.2   Compare the Contrast-detail Characteristic with the Normal values given in the Reference (IPSM Report 32).

Compare and comment on the two different Contrast-detail functions.
8.1.5.3   Compare the difference in video signal amplitude and II entrance dose rate for a screen with adjusted and mis-adjusted contrast and brightness.

Compare the noise on the video signal in both of the above cases.
8.1.5.4   Compare and comment on the difference in video signals for two different II image field sizes.

8.1.6   Observations, Interpretations, Conclusions

Comment on the effectiveness of the Fluoroscopic X-ray Equipment and explain why the patient dose during fluoroscopy is greater than that in radiography.
Comment on the possible areas of application of the different TV cameras.
Observe the plotted contrast-detail functions and comment on their dependence on II image field size.
Describe a video signal whose parameters are NOT-Acceptable.

8.1.7   References

..........................................................

Verification (Signature and date by the trainer)
Verbal Memory + Image Memory

For Assessment of X-ray Tube Leakage Radiation

Close the X-ray tube diaphragm and place the tube down on the X-ray table.

Surround the X-ray tube with at least 6 big X-ray cassettes with films, forming a closed volume (cubicle) around the X-ray tube housing (number the films).

Image Database in 3 volumes (3 CD-ROMs): DR, NM, RT

System requirements: PC with Windows 95/98; min. 486 (100 MHz) min. 16 MB; min. 1 MB graphics (600x800/256); CD-ROM: min. x4

Image Browser: ThumbsPlus 4 (runs from the CD-ROM)
Image Database functions

Browsing
Slides (120x160)
Image Info
Annotations
Keywords
Boolean search
Sorting
Visualisation (up to 20 images)

Dr Slavik Tabakov

INTERACTIVITY

Remember to EXIT when you finish

Help

Image Database functions

Browsing
Slides (120x160)
Image Info
Annotations
Keywords
Boolean search
Sorting
Visualisation (up to 20 images)

Each CD includes a freeware Thumbs browser
Text is still crucial – for keywords and acknowledgement
EMERALD CD-ROMS

- Image Database (as before)
- E2 Internet site with:
  * Navigational structure
  * Text of tasks (from Workbooks)
  * Images from database (smaller)
  * Hyperlinks: text>image
  * Course Guide

Necessities (min):
- PC 100MHz, CDx4, 32 MB, 2MB graph.
- Internet browser (IE5 or N4)
- Acrobat Reader

Adobe Acrobat functions
print

Dr. Slavik Tabakov
14

Dr. Slavik Tabakov

Edited tasks and New tasks
hyperlinked with images
more examples

Scrollable frames

Two main windows
- Text window
- Image window

Manual Treatment Planning for Intracavitary Brachytherapy
A cervix cancer treatment.

The 3D Re-optimization, with its dose distribution, offers HDR techniques are
used with 3D optimization if possible; dose distribution in normal, normal and
interstitial plans. Reoptimization of the apertures on the and the ang hart
section of the applicator. Portal and internal films. Vaginal cylinder with
introducer probe, intram and normal films.

Back to RT. 14
- EMERALD is a resource, which could support various training schemes, and not a replacement of these. Its greatest value is the flexibility offered - from one side the training tasks can be used ‘as is’, building to a full training package. Alternatively they can be used to substitute existing training schemes and suggest further training areas.

- EMERALD Image Database has been very useful for training. Additionally it has huge educational potential for Universities - from keyword search to image processing.

- EMERALD electronic training materials have been accepted very well by young colleagues.

Project Emerald - Internet Issue ( EMERALD II )

- EMERALD materials&CDs used in 46 countries
- Dedicated Internet Site for e-learning and training www.radfys.lu.se/emerald2
- A new EU Leonardo project EMIT – to develop training Ultrasound and Magnetic Resonance Imaging

http://www.emerald2.net
EU Leonardo Project
EMIT - European Medical Imaging Technology Training
4 countries, led by King’s College London

As in EMERALD – EMIT is based on:
Identical structure and functions of the U/S and MRI Image databases
The collection of images in the database directories follows the chapter organisation of the Workbook with tasks

EMIT project innovations
Software dependent!

MRI and US new simulations and video
10-11 October 2003, ICTP, Trieste, Italy (experts from 26 countries)

Dr Slavik Tabakov

Conference of the EU Minsters for Education, Maastricht (NL) 14-16th December 2004. From all 4000 EU educational projects in the last 10 years, 32 were nominated, and EMIT Consortium was announced winner of the first EU LEONARDO DA VINCI AWARD

The winning EU Leonardo project EMIT (European Medical Imaging Technology Training, 2001-2004) is a continuation of a previous Leonardo project EMERALD (European Medical Radiation Learning Development, 1995-2001).
EMERALD and EMIT materials are now used in 65 countries

"EMERALD and EMIT materials are unmatched in breadth, depth, global impact and life cycle..."

Dr. Slavik Tabakov
International Medical Physics College at ICTP, Trieste, Italy
- IAEA - IOMP - EFOMP - AAPM

The Emerald and EMIT users: the biggest success is the ease of use
EMERALD Update

easy in nature, but difficult to make…

Three ways to update:
- New fields and tasks
- New images for the IDB
- New e-materials on Internet

- Internet subscription - none
- Internet use of materials – limited
- 99% are “browsing” the CD

…perhaps this will change in time

“training-on-demand” on Lund’s server

New Medical Physics Dictionary (covering both EMERALD and EMIT)

Translates terms (approx. 3500) to/from 9 languages

www.emitdictionary.co.uk
EMIT modules on MRI and U/S Imaging (2 CDs for MRI):
- Text pages (Workbooks+Guide, all translated) - 1300 pages
- Image Database volume - 1800 images (165 MB);
- e-books volume (text+images+captions) - 13500 files (210 MB)
- Overall volume of EMERALD + EMIT – approx. 950 MB
- Time for development – 10 years
WELCOME TO NEW LANGUAGES!