First National Digital Mammography Survey in Portugal
- Findings and Recommendations -

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(*affiliated to FEUCP when the survey was performed. Currently affiliated to King’s College Hospital)
Introduction
Some facts about breast cancer

“...is the top cancer in women worldwide and is increasing particularly in developing countries”

WHO, 2011
Some facts about breast cancer

- 1500 breast deaths/year
- 4500 new cases/year
- 1% ♂ (male)
- 10% women will develop breast cancer
- 90% curable if diagnosed early

LPCC, 2011
Some facts about mammography

“the only screening method that has proven to be effective (...) can reduce mortality by 20 to 30% in women over 50 yrs old when screening coverage is over 70% (IARC, 2008).

“Mammography screening is very complex and resource intensive.”

WHO, 2011
What may go wrong?

Missed breast cancers

- Breast: dense, thick
- Tumor: subtle, masked, multicentric, multifocal
- Technique: positioning, exp factors, processing
- Observer: perception issues, lack of experience

Kamal et al, 2007
What may go wrong?

Missed breast cancers? How can be reduced?

“(…) be strict about **positioning** and **technical requirements** to optimize image quality”

Annesa et al, 2003
Technological advances in mammography

- **Screen-Film Mammography (SFM)**
  - 1960’s

- **Computed Radiography (CR)**
  - 1980’s

- **Direct Radiography (DR)**
  - 1990’s
International guidance on QA in mammography

ACR Guidelines 1999

EU Guidelines 2006

IAEA 2011

Minist. Saúde Desp. 258/2003

Manual de Boas Práticas em Radiologia
Objectives
How is mammography in Portugal?

Focus: digital mammography
How is mammography in Portugal?

A broad perspective

Goals

People

Processes & Methods

Technology

Results
Literature survey – peer review

Questions to be answered

1. How many mammography systems are installed in the country? What type of technology is available?

2. How is staff (radiographers and radiologists) being trained in mammography?

3. How is the performance of DM systems in clinical use?

4. How do practice in mammography comply with international guidelines of best practice? Is there room for improvement?
Methods
Phase 1 – characterisation of technology

• Literature search

• Information request
  – healthcare authorities: DGS; 7 ARS
  – Manufacturers and distributors

• Questionnaires
Phase 2 – characterisation of practice

- Targeted questionnaires
  - breast radiographers
  - chief radiographer
  - breast radiologists

- Data collected
  - Type of institution
  - Education and training
  - Mammography technique in use
  - Radiology practice (reading and interpretation)
  - Quality control
  - Views on impact of DM
Phase 3 – technical performance

• Selection criteria
  – Type of technology (CR, DR)
  – Manufacturer
  – Geographical location
  – Type of provider (public, private, cooperative)
  – Practical issues (time and resources available)
Phase 3 – technical performance

**Tube & generator**
- Caracterização
- Exactidao
- Repetibilidade

**X-ray beam dosimetry**
- Caracterização
- Output
- HVL
- Dosimetria

**Detector tests**
- Aligment
- Uniformity
- Ghosting (DR)
- Image quality (TORMAM, TORMAX)
- Detector response
- MTF, NPS, DQE
- AEC
- Interplate variability (CR)
- Fading (CR)

**Compression device**
- Thickness
- Pressure

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**CR**
Duration ~4h/unit

**DR**
Duration ~ 3h/unit
Results – fase 1 (technology)
## Installed base of mammography systems

<table>
<thead>
<tr>
<th></th>
<th>Private</th>
<th>Public</th>
<th>Screening</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CR</strong></td>
<td>211</td>
<td>33</td>
<td>28</td>
<td>15</td>
<td>287 (64%)</td>
</tr>
<tr>
<td><strong>DR</strong></td>
<td>47</td>
<td>16</td>
<td>3</td>
<td>1</td>
<td>67 (15%)</td>
</tr>
<tr>
<td><strong>SFM</strong></td>
<td>23</td>
<td>4</td>
<td>1</td>
<td></td>
<td>28 (6%)</td>
</tr>
<tr>
<td><strong>Not known</strong></td>
<td>57</td>
<td>3</td>
<td>3</td>
<td></td>
<td>63 (14%)</td>
</tr>
<tr>
<td><strong>In transition</strong></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1 (0.3%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>339 (76.0%)</td>
<td>56 (12.6%)</td>
<td>31 (7.0%)</td>
<td>20 (4.4%)</td>
<td>446 (100%)</td>
</tr>
</tbody>
</table>

* number of DR systems more than doubled (31…76) in 2 years (2010-12)
Distribution of mammography systems

Portugal

Computed Radiography

Direct Radiography
Results – phase 2
(practice & organisational matters)
Response rate

- Questionnaires sent to 269 hospitals & clinics
- Response rate: 24%

<table>
<thead>
<tr>
<th></th>
<th>Norte</th>
<th>Centro</th>
<th>LVT</th>
<th>Alent</th>
<th>Algar</th>
<th>Mad</th>
<th>Total</th>
<th># centers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiolo</td>
<td>15</td>
<td>11</td>
<td>30</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>69</td>
<td>53</td>
</tr>
<tr>
<td>Radiog</td>
<td>26</td>
<td>13</td>
<td>50</td>
<td>10</td>
<td>15</td>
<td>4</td>
<td>118</td>
<td>65</td>
</tr>
<tr>
<td>Chief Radiog</td>
<td>10</td>
<td>9</td>
<td>27</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>59</td>
<td>59</td>
</tr>
</tbody>
</table>
Sample characteristics

- Profile of the institutions that?

<table>
<thead>
<tr>
<th>Region</th>
<th>Other</th>
<th>Private</th>
<th>Public</th>
<th>Screening</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>6.8%</td>
<td>10.0%</td>
<td>6.8%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Centre</td>
<td>5.1%</td>
<td>8.5%</td>
<td>1.7%</td>
<td>1.7%</td>
</tr>
<tr>
<td>LVT</td>
<td></td>
<td>32.2%</td>
<td>6.8%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Alentejo</td>
<td>3.4%</td>
<td>1.7%</td>
<td>1.7%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Algarve</td>
<td>6.8%</td>
<td>1.7%</td>
<td>1.7%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Madeira</td>
<td>1.7%</td>
<td>1.7%</td>
<td>1.7%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>
## Mammography workload

<table>
<thead>
<tr>
<th></th>
<th>Shifts/week</th>
<th>Hours/Shift</th>
<th>Exams/Shift</th>
<th>Mammography/Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>5.8 ± 1.6</td>
<td>6.0 ± 0.2</td>
<td>17.7 ± 6.4</td>
<td>2.9 ± 1.1</td>
</tr>
<tr>
<td>Private</td>
<td>8.3 ± 2.3</td>
<td>4.8 ± 0.5</td>
<td>19.7 ± 2.1</td>
<td>4.4 ± 0.5</td>
</tr>
<tr>
<td>Screening</td>
<td>5.6 ± 2.3</td>
<td>7.0 ± 1.3</td>
<td>55.0 ± 3.2</td>
<td>8.1 ± 1.5</td>
</tr>
<tr>
<td>Other</td>
<td>2.3 ± 0.7</td>
<td>3.3 ± 1.8</td>
<td>11.7 ± 6.4</td>
<td>3.6 ± 1.1</td>
</tr>
</tbody>
</table>
Mammography guidance in use

- Manufacturer: 63%
- Local protocol: 29%
- National Guideline: 2%
- International Guideline: 6%
Training in mammography

Radiologists

- Training in DM: 77%
- No Training in DM: 23%

Radiographers

- Training in DM: 67%
- No Training in DM: 33%

~ 61%:
  - Courses (PT and abroad)
  - Manufacturer
  - Sessions 1w (93%)

~ 42%:
  - Manufacturer Workshops
  - Short-term sessions 1-2d (73%)
Self-assessed training needs

- Radiographers:
  - QC: 7%
  - Intervention: 38%
  - Optimisation: 55%
  - Dosimetry: 51%
- Radiologists:
  - Artifact recognition: 1%
  - Dosimetry: 48%
  - Tomosynthesis: 55%

No answer: 1%
Radiologists practice (image viewing/reporting)

Hardcopy or softcopy?

- Electronic display: 53%
- Hardcopy: 33%
- Both: 14%

Reporting time (digital compared to analogue)?

- Comparable: 52%
- Less time: 19%
- More time: 29%
Use of post processing tools (radiologists)
Quality assurance practice

![Bar chart and pie chart showing quality assurance practice.]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Weekly</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Monthly</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Quarterly</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>6-month.</td>
<td>4</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Annual</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

- Yes: 71%
- No: 29%
Reject analysis

- Performed in 35% of institutions only
  - Various causes for rejects

- Technical parameters
- Image processing
- Artifacts
- Patient motion
- Skin folds
- No pectoral muscle
- Other
Results – phase 3
(technical performance)
52 Equipments (15% of total)

- 18 DR (27%)
- 34 CR (12%)
Alignment of light field to X-ray field

<table>
<thead>
<tr>
<th>Alignment</th>
<th>CR</th>
<th>DR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass</td>
<td>14% (4)</td>
<td>64% (9)</td>
<td>30% N=13</td>
</tr>
<tr>
<td>Fail</td>
<td>86% (25)</td>
<td>36% (5)</td>
<td>70% N=30</td>
</tr>
</tbody>
</table>
Artefacts

Expected

Causes

- Overuse of image plates
- CR reader mechanical issues

Observed
MGD (PMMA phantom; AEC)

This study

Mamography unit ID
### $S_d\text{NR}$ (PMMA phantom; AEC)

<table>
<thead>
<tr>
<th>Mammography equipment</th>
<th>Small breast</th>
<th>Medium breast</th>
<th>Large breast</th>
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<tbody>
<tr>
<td><strong>CR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agfa</td>
<td>SdNR</td>
<td>SdNR</td>
<td>SdNR</td>
</tr>
<tr>
<td>Fuji</td>
<td>SdNR</td>
<td>SdNR</td>
<td>SdNR</td>
</tr>
<tr>
<td>Carestream/Kodak</td>
<td>SdNR</td>
<td>SdNR</td>
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</tr>
<tr>
<td><strong>DR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GE 2000</td>
<td>SdNR</td>
<td>SdNR</td>
<td>SdNR</td>
</tr>
<tr>
<td>GE DS</td>
<td>SdNR</td>
<td>SdNR</td>
<td>SdNR</td>
</tr>
<tr>
<td>Fuji Amulet</td>
<td>SdNR</td>
<td>SdNR</td>
<td>SdNR</td>
</tr>
<tr>
<td>Siemens Inspiration</td>
<td>SdNR</td>
<td>SdNR</td>
<td>SdNR</td>
</tr>
</tbody>
</table>

- **SdNR < Accep/Achiev**
- **Accep < SdNR < Achiev**
- **SdNR > Accep/Achiev**
### S\textsubscript{d}NR (PMMA phantom; AEC)

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<tr>
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<td>SdNR</td>
<td>MGD</td>
<td>SdNR</td>
</tr>
<tr>
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<td>MGD</td>
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<td><strong>DR</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>GE 2000</td>
<td>SdNR</td>
<td>MGD</td>
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</tr>
<tr>
<td>GE DS</td>
<td>SdNR</td>
<td>MGD</td>
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</tr>
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<td>Siemens Inspiration</td>
<td>SdNR</td>
<td>MGD</td>
<td>SdNR</td>
</tr>
</tbody>
</table>

**Color Coding**
- **MGD > Accep/Achiev**
- **Accep < MGD < Achiev**
- **MGD < Accep/Achiev**
Image Quality (TORMAM)

- Image quality
  - 200 images (under AEC)
  - 4 trained observers
DR - Image Quality & MGD (PMMA)

![Graph showing Image Quality Score and MGD (mGy) for various Mammography Units (DR systems).](image)

- **MGD [mGy]**
- **TORMAM Score**
MGD (from clinical exposure data)

• Exposure data collected from
  – 38 mammography systems
    • 25 CR
    • 13 DR
  – 2121 exams/patients
  – 8484 exposures (= images)
MGD (from clinical exposure data)

DR: 1.54 mGy (CC)
CR: 1.85 mGy (CC)

DR: 1.68 mGy (MLO)
CR: 2.10 mGy (MLO)
Dose reference levels

- MGD (from clinical exposure data)
- Exposure data of MLO projections
Dose reference levels

Dose Reference Levels CR
- 2.2 mGy

Dose Reference Levels DR
- 1.5 mGy

UK - 3.5 mGy (SFM)

Young et al proposes 2.2 mGy (CR) and 1.5 mGy (DR)
Conclusions
Mammography equipment

• Limited peer review data

• No national equipment registry with updated information and relevant technical detail

• The majority (76%) of mammography systems are CR technology

• Number of DR systems more than doubled in 2 years (31…67)
Organisational matters

• Workload is higher in private & screening centres

• Use of equipment is based on manufacturers’ guidance

• Training needs identified by radiologists and radiographers (dosimetry, artefact recognition, tomosynthesis)

• 33% of radiologists still report on hardcopy format
Organisational matters

• QC not performed in 30% of the participant centres

  – Reject analysis is not implemented in the majority of centres

  – Lack of clarity regarding servicing (manufacturer) and QC (independent)
Equipment performance

• Mean Glandular Dose (MGD)
  – Higher MGD for CR systems compared to DR
  – $\text{MGD}_{\text{PMMA}} < 2.5 \text{ mGy}$ (EUREF acceptable ref.) for vast majority of systems

• SdNR lower than expected (AEC calibration?) particularly for CR systems

• Image quality
  – Wide range of image quality
    • CR systems (score 30 to 100)
    • DR system (score 61 to 91)
Recommendations
Recommendations

To be discussed and formulated in collaboration with you - the stakeholders.
Aknowledgments

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