Mammography – Chapter 8

Kalpana Kanal, Ph.D., DABR
Assistant Professor, Diagnostic Physics
Dept. of Radiology
UW Medicine

a copy of this lecture may be found at:
http://courses.washington.edu/radxphys/PhysicsCourse.html

RSNA/AAPM Web Module
Curriculum

Fundamental Knowledge:
1. Describe unique features of mammography tubes and how they affect the x-ray spectrum produced.
3. Review magnification techniques.
4. Describe the characteristics of the different detectors used in mammography, e.g. screen-film and full-field digital mammography systems.
5. Discuss breast radiation dosimetry.
6. Discuss MQSA (Mammography Quality Standards Act) and its effect on mammography image quality and dose.

RSNA/AAPM Web Module
Curriculum

Clinical Application:
1. Describe appropriate uses of the different targets and filters available in mammography systems.
2. Explain when magnification is indicated.
3. Associate image quality changes with radiation dose changes.
4. What are the MQSA training and CME requirements for radiologists, technologists and physicists?
5. What are the QA requirements of MQSA for digital mammography?

Clinical Problem-Solving:
1. Identify factors influencing image contrast and detail as they relate to the visualization of lesions in mammography.
2. Discuss possible image artifacts in mammography and corrective methods that could be used to reduce them.

1. Introduction

- Mammography is a radiographic modality used for detecting breast pathology and cancer
- Approximately 1 in 8 women will develop breast cancer over a lifetime in USA
- Breast cancer accounts for 32% of cancer incidence and 18% of cancer deaths in women in the United States
- Breast cancer screening depend on x-ray mammography because it is a low-cost, low-radiation-dose procedure that has the sensitivity for early detection and improved treatment
- In 1992, the federal Mammography Quality Standards Act (MQSA) came into existence to ensure that all women have access to quality mammography with optimal patient care and follow-up
1. Introduction

Continuing refinements in technology have vastly improved mammography over the last 15 years. 

- Increasing use of tomosynthesis
- Tomosynthesis

Digital Mammography

Tomosynthesis

Mammographic features characteristic of breast cancer are:
- Mass with spiculated margins
- Clustered heterogeneous microcalcifications
- Architectural distortion

1. Introduction

Screening Mammography – Identify Cancer
- the AMA, ACS and ACR recommend a baseline mammogram by age 40, biennial examinations between ages 40 and 50, and yearly examinations after age 50
- NCI recommends women in their 40s, 50s and older should be screened every one to two years with mammography
- Require craniocaudal (CC) and mediolateral oblique (MLO) views of each breast

Diagnostic Mammography – Evaluate Abnormalities
- may require additional views, magnification views, spot compression views, stereotactic biopsy or other studies using other modalities
1. Mammography Imaging Modalities

- Ultrasound Breast Imaging
  - used for differentiating cysts (typically benign) from solid masses (often cancerous), which have similar appearances on the mammogram
  - provides biopsy needle guidance for extracting breast tissue specimens

- MRI
  - has wonderful tissue contrast sensitivity
  - useful for evaluating silicone implants
  - accurately assess the stage of breast cancer involvement

MRI Evaluation of the Contralateral Breast in Women with Recently Diagnosed Breast Cancer

UW - Dr. Constance Lehman


1. Modern Mammography

- Detection of minute calcifications important
  - high correlation of calcification patterns with disease

- Best differential between the tissues is obtained at low x-ray energies
  - However, the high absorption results in a high tissue dose and long exposure time

- Mammography equipment
  - Low contrast sensitivity
  - High resolution
  - Low dose

Dedicated Mammography Equipment

- Specialized X-ray Tubes
- Breast Compression Devices
- Optimized Screen/Film detector systems

1. Modern Mammography

- Breast is composed of fatty tissue, glandular tissue and a 50/50 combination of both
- Normal and cancerous tissues in the breast have small x-ray attenuation differences between them and this difference decreases with increasing energy
- Need x-ray equipment specifically designed to optimize breast cancer detection

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1. X-Ray Tube Design

- 0.3 mm (contact) and 0.1 mm (magnification) focal spot sizes
- Small focal spot minimizes geometric blurring and maintains spatial resolution
- Peak Kilovolt below 35 kVp
- 100 mA for large (0.3 mm) focal spot
- 25 mA for small focal spot
- Anodes: Molybdenum (Mo), and dual track Mo/Rhodium (Mo/Rh) targets are used
- Targets used in combination with specific tube filters to achieve optimal energy spectra

- Heel effect – significant drop in x-ray intensity on the anode side of the field (self-filtration through anode) is minimized.
- Thus cathode-anode axis is placed from the chest wall (greater penetration of x-rays) to the nipple in breast imaging.
- More uniform exposure is achieved.

Molybdenum (Mo) and Rhodium (Rh) are used for mammography targets and produce characteristic x-ray peaks at 17.5 and 19.6 keV (Mo) and 20.2 and 22.7 keV (Rh)

1. Tube Port, Tube Filtration & Beam Quality

- Monoenergetic x-rays of 15 to 25 keV are optimal choice to achieve high subject contrast at lowest possible radiation dose
- Polychromatic spectra compromises:
  - High-energy x-rays in the bremsstrahlung spectrum diminish subject contrast
  - Low-energy x-rays in the bremsstrahlung spectrum have inadequate penetration and contribute to patient dose without providing a useful image
- Optimal x-ray energy is achieved by use of specific target materials and filters to remove the low- and high-energy x-rays

1. Tube Port, Tube Filtration & Beam Quality

- 1-mm thick Beryllium used as the tube port
  - Beryllium provides both low attenuation and good structural integrity

- Added tube filters of the same element as the target reduce the low- and high-energy x-rays in the x-ray spectrum and allow transmission of characteristic x-ray energies

- Common target/filters in mammography include
  - Mo/Mo
  - Rh/Rh
  - Mo/Rh

A Mo target with Rh filter is used for imaging thicker and denser breasts since this produces slightly higher effective energy than Mo/Mo.

20 – 23 keV effective energy leading to increased penetration of thick and/or dense breasts.

Rh target with Rh filter provides the highest effective energy beam and is useful for the thickest and densest breasts.

Tungsten (W) targets with Mo and Rh filters not usually used but sometimes are available with the mammography unit.

1. Half Value Layer (HVL)
- The HVL ranges from 0.3 to 0.45 mm Al in mammography
- depends on kVp, compression paddle thickness, added tube filtration, target material and age of tube
- In general, HVL increases with higher kVp and higher atomic number targets and filters
- The approximate HVL in breast tissue is ~ 1 to 2 cm (strongly dependent on tissue composition: glandular, adipose and fibrous).
- Thus a 4 cm breast will attenuate \(1-1/2^4 = 0.93\), or 93% of the incident primary radiation
- [Reduction in beam intensity or fraction transmitted is \(1/2^n\) and attenuation is \((1-1/2^n)\)]

2. X-Ray Generator
- A dedicated mammography x-ray generator is similar to a standard x-ray generator in design and function with some minor differences.
- Generator power rating is 3-10 kW
- The voltage supplied to the x-ray tube (22-40 kVp),
- Automatic Exposure Control (AEC) circuitry different
- High-frequency generators are the standard for mammography

1. Collimation
- Fixed-size metal apertures or variable field size shutters collimate the x-ray beam
- The field size matches the film cassette sizes
  - 18 x 24 cm or 24 x 30 cm
- Collimator light and mirror assembly define the x-ray field
  - X-ray field – light field congruence must be within 2% of SID for any edge
  - The useful x-ray field must extend to the chest wall edge without field cutoff

2. Automatic Exposure Control (AEC)
- The AEC, also called a phototimer, uses a radiation sensor (or sensors), an amplifier, a voltage comparator, to control the exposure
- AEC detector is located underneath the cassette in mammography unlike conventional radiography

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2. Automatic Exposure Control (AEC)

- If the transmission of photons is insufficient to turn the exposure off after an extended exposure time, a backup timer terminates the exposure.
- For a retake, the operator must select a higher kVp for greater beam penetrability and shorter exposure time.
- Inaccurate phototimer response can be caused by breast tissue composition heterogeneity, defective cassette, faulty detector, inappropriate kVp setting etc.
- Film response to very long exposure times (MAG mode) results in reciprocity law failure and inadequate film density.

For a retake, the operator must select a higher kVp for greater beam penetrability and shorter exposure time.

2. Technique Chart

- Technique charts are useful guides to determine the appropriate kVp for specific imaging tasks, based on breast thickness and breast composition.
- Proper kVp is essential for a reasonable exposure time, defined as a range from approx. 0.5 to 2.0 seconds, to achieve an optical density of 1.5 to 2.0.

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3. Compression

- Breast compression is necessary.
  - It reduces overlapping anatomy and decreases tissue thickness of the breast.
  - Less scatter, more contrast, less geometric blurring of the anatomic structures, less motion and lower radiation dose to the tissues.

Use a low attenuating lexan paddle attached to a compression device.
- 10 to 20 newtons (22 to 44 pounds) of force is typically used.
- A flat, 90° paddle (not curved) provides a uniform density image.
- Parallel to the breast support table.
- Principal drawback of compression is patient discomfort.

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- Parallel to the breast support table.
- Principal drawback of compression is patient discomfort.
3. Compression

Spot compression uses small paddles.


3. Scatter Radiation

- Scatter radiation degrades subject contrast.
- The amount of scatter increases with breast thickness and breast area, and is relatively constant with kVp (25-35 kVp).
- Without scatter rejection, only 50 to 70% of the inherent subject contrast will be detected.

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3. Magnification

- Advantages
  - Magnification of 1.5x to 2.0x is used.
  - Increased effective resolution of the image receptor by the magnification factor.
  - Small focal spot size used.
  - Reduction of scatter.

Magnification of 1.5x to 2.0x is used.
Increased effective resolution of the image receptor by the magnification factor.
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Reduction of scatter.

Magnification Views

3. Magnification

- Disadvantages
  - Geometric blurring caused by the finite focal spot size (more on cathode side)
  - Breast dose in general similar to contact mammography
  - Long exposure times (small focal spot, low mA)
  - Patient motion and blur

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- Long exposure times (small focal spot, low mA)
- Patient motion and blur

- Take Home Points

  - Breast Cancer – masses, microcalcifications and architectural distortions in breast
  - Low energies used to optimize contrast (photoelectric effect)
  - Specialized equipment needed
    - Improve contrast and resolution, decrease dose
  - kVp range 22-40 kVp
  - Molybdenum and Rhodium targets used in mammography
    - Characteristic radiation for Mo at 17.5 and 19.6 keV
    - For rhodium, 20.2 and 22.7 keV
  - Heel effect due to attenuation in target
    - Chest wall on cathode side and nipple on anode side to get uniform exposure

3. MTF in magnification mammography

- Take Home Points

  - Common target/filters in mammography include
    - Mo/Mo (thin breasts), Rh/Rh (thickest, dense breasts), Mo/Rh (thicker, denser breasts)
  - Tungsten target available on some units but not used
  - Generator similar to conventional radiography except for
    - Lower power rating, different AEC circuitry, low kVp used
  - 18 x 24 and 24 x 30 cm cassettes used
  - AEC detector is located underneath the cassette in mammography unlike conventional radiography
Take Home Points

- Breast compression is necessary
  - reduces overlapping anatomy, decreases tissue thickness of the breast, less scatter, more contrast, less motion and lower radiation dose to the tissues
- Scatter reduced by grids
  - 5:1 grid ratio
  - Bucky factor of 2 to 3
- Magnification of 1.5 to 2 times in mammography
  - Increased resolution, decreased scatter, increased dose, long exposure times, motion, increase in geometric blur with increased magnification

4. Screen/Film Cassettes

- Cassettes have a single phosphor screen and single emulsion film
- Mamography screen-film speeds (sensitivity):
  - regular (100 or par speed) (12-15 mR required)
  - medium (150 – 190 speed)
- For comparison, a conventional “100-speed” screen film cassette requires about 2 mR

4. Film Processing

- Film processing is a critical step in the mammographic imaging chain
- Consistency in film speed, contrast, optical density levels are readily achieved by following the manufacturer’s recommendations
4. Film Sensitometry

- A film processor quality control program is required by Mammography Quality Standards Act of 1992 (MQSA) regulations, and daily sensitometric strips prior to the first clinical images must verify acceptable performance.

- Film sensitometry confirms proper film contrast, speed and base + fog values of mammographic film.

- Typical fog values are 0.17 – 0.2 OD, Dmax = 3.8 – 4.0 OD and the target film OD ranges from 1.2 – 1.8.

4. Extended Cycle Processing

- Extended cycle processing (or push processing) increases the speed of some single emulsion mammography films by extending the developer immersion time by a factor of two (usually from ~ 20 to ~ 40 seconds).

- The rationale is to completely develop all latent image centers, which does not occur with standard processing.

- Up to 35% to 40% decrease in required x-ray exposure is obtained compared to standard processing for same OD.

- On conventional 90 second processor, the processing time is extended to 180 seconds.
4. Film Viewing Conditions

- Optimal film viewing conditions are important in detecting subtle lesions.
- Mammography films are exposed to high optical densities to achieve high contrast, view boxes providing a high luminance are necessary.
- The luminance of a mammography viewbox should be at least 3000 cd/m².
- In comparison, a typical viewbox in diagnostic radiology is about 1500 cd/m².

Question

- 1. Which of the following is not a modern mammography target/filter combination for screen-film?
  - A. Mo/Mo
  - B. Mo/Rh
  - C. Rh/Rh
  - D. W/Al
  - E. W/Rh
Rhodium/rhodium target/filter combinations should be used only when:
- Thick, dense breasts are imaged.
- Thin, adipose breasts are imaged.
- Maximum subject contrast is critical.
- The molybdenum anode is too hot.
- High resolution images are necessary.

The use of a 5:1 mammography grid _____ the breast dose by _____ time(s) that without a grid.
- Decreases, 1.0
- Increases, 1.0
- Decreases, 2.5
- Increases, 2.5
- Increases, 5

Compensation for the heel effect occurs when:
- Orientation of the cathode/anode axis perpendicular to the chest wall/nipple.
- Extended processor development time.
- Orientation of the cathode over the chest wall and anode over the nipple.
- Larger field of view (24 * 30 cm) cassettes.
- Orientation of the cathode over the nipple and the anode over the chest wall.

1. The K-characteristic x-rays of molybdenum target tubes comprise a significant portion of the total x-ray flux. These x-rays have energies predominantly between _________ keV and _________ keV
- A. 10, 12
- B. 15, 16
- C. 17, 20
- D. 24, 26
- E. 59, 69
Question

1. The filtration in mammography units primarily transmits the characteristic x-rays. The very low-energy bremsstrahlung x-rays are filtered because they contribute to ___________, and the higher energy bremsstrahlung x-rays are filtered because they contribute to ___________.

- A. tube heating, off-focus radiation
- B. heel effect, focal spot blooming
- C. radiation dose, loss of contrast
- D. grid cut-off, septal penetration
- E. coherent scatter, K-edge photons

5. Radiation Dosimetry

- Risk of carcinogenesis from the radiation dose to the breast is of concern thus monitoring of dose is important and is required yearly by MQSA (Mammography Quality Standards Act of 1992)
- Indices used in Mammography
  - Entrance Skin Exposure (ESE)
    - the free-in-air ionization chamber measurement of the entrance skin exposure of the breast
    - typical ESE values for a 4.5 cm breast are 500 to 1000 mR
  - Half Value Layer (HVL)
    - Typical HVL from 0.3 to 0.4 mm Al for 25 – 30 kVp

5. Radiation Dosimetry

- Glandular tissue is sensitive to cancer induction by radiation
- Average Glandular Dose
  - Dependent on the composition of breast, breast thickness, HVL and kVp of beam
  - The Roentgen to Rad conversion factor, $D_N$ is used to convert the measured ESE to glandular dose
    - $D_g = D_N \times X_{ESE}$
5. Radiation Dosimetry

- Factors affecting breast dose
  - Higher kVp increases beam penetrability (lower ESE and lower average glandular dose), but decreases inherent subject contrast
  - ↑ kVp and ↓ mAs will result in low dose because of greater penetrability (use higher kVp)

  ![Graph showing effect of kVp and mAs on dose]


- Increased breast thickness requires increased dose
  - Vigorous compression lowers breast dose by reducing thickness


  c.f. RSNA/AAPM web module: Image Quality and Dose in Mammography

- Rh/Rh combination will result in lowest average dose, followed by Mo/Rh and Mo/Mo (use Rh for thicker, denser breasts)
- Screen/film speed and film processing conditions (use faster screen film or digital detectors)
- Higher OD target on film will ↑ dose
  - Use of a grid will ↑ dose
  - Tissue composition of the breast
    - Glandular tissue will have higher breast dose due to increased attenuation and a greater mass of tissue at risk


The MQSA limits the average glandular breast dose to 3 mGy or 300 mrad per film for a compressed breast thickness of 4.2 cm and a breast composition of 50% glandular and 50% adipose tissue (using the MQSA approved mammography phantom)

If the average glandular dose for this phantom exceeds 3 mGy, mammography cannot be performed

The average glandular dose for this phantom is typically 1.5 to 2.2 mGy per view or 3 to 4.4 mGy for two views for a film optical density of 1.5 to 2.0
5. Risks and Benefits

- Based on AGD of 3 mGy, the increased breast cancer risk from radiation is 6 per million examined women.
- This is equivalent to dying in an accident when traveling 5000 miles by airplane or 450 miles by car.
- Screening in 1 million women is expected to identify 3000 cases of breast cancer.
- The breast cancer mortality rate is about 50%.
- Screening would reduce the mortality rate by about 40%.
- That would potentially mean 600 lives being saved due to screening.
- The benefits of getting a mammogram far outweigh the risks associated with the radiation due to the mammogram.

Take Home Points

- Single-screen and single emulsion film used
  - 15-20 lp/mm resolution
- Film processing is very important.
- A film processor quality control program is required by Mammography Quality Standards Act of 1992 (MQSA) regulations.
- The luminance of a mammography viewbox should be at least 3000 cd/m².
- Glandular tissue is sensitive to cancer induction by radiation.

6. Stereotactic Breast Biopsy

- Average glandular breast dose limited to 3 mGy or 300 mrad per film for a compressed breast thickness of 4.2 cm, 50/50 glandular/adipose breast composition.
  - Increasing kVp reduces dose.
  - Increased breast size increases dose.
  - Vigorous compression lowers breast dose by reducing thickness.
- Risk of mammogram induced breast cancer is far less than the risk of developing breast cancer.

Take Home Points

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- Increased breast size increases dose.
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- Risk of mammogram induced breast cancer is far less than the risk of developing breast cancer.
6. Stereotactic Breast Biopsy

- Greater shift occurs when lesions positioned more cranially in the breast.

7. Full-Field Digital Mammography (FFDM)

**Advantage**
- Wide dynamic range (1000:1) compared with SFM (40:1)
- Dynamic image manipulation
- Ability to post-process
- Soft-copy read accompanied by computer-aided-diagnosis (CAD)
- 3D imaging

**Radiographics 2004;24:1749**

**Radiographics 2004;24:1750**
7. SFM vs. FFDM

**SFM:** Half mAs, Automatic exposure control, Double mAs

**FFDM:** Same technique factors as SFM, W/L adjusted

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7. Technologies for FFDM

- **Indirect Capture**
  - a scintillator such as cesium iodide (CsI) absorbs x-rays and generates a light scintillation
  - detected by an array of photodiodes or charge-coupled devices (CCDs)
  - Resolution degradation

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7. Technologies for FFDM

- **Direct Capture**
  - X-ray photons are directly captured by a photoconductor such as amorphous selenium (a-Se), which converts the absorbed x-rays directly to a digital signal
  - Spatial resolution limited to pixel size

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7. Technologies for FFDM – Indirect Capture

Slot Scanning with a Scintillator and a CCD Array

(SenoScan; Fischer Imaging (now Hologic))

- A narrow slot-detector and a narrow fan beam of x-rays are scanned synchronously across the full field of view to cover the entire breast
- System consists of phosphor (thallium-activated CsI) with a fiberoptic coupling to a CCD
- Detector is 1 cm wide and 22 cm long, consists of 4 CCDs abutted together

In this system, the digital detector array is constructed from an a-Si thin-film transistor (TFT) matrix deposited on a glass substrate
- The CsI scintillator is deposited on the a-Si detector
- Each light-sensitive diode element is connected by TFTs to control and data lines so that charge produced in the diode is read out in response to light emission from the scintillator

The GE Senographe 2000D system was the first FFDM system to be approved by the FDA in USA
- 1,920 x 2,304 detector elements on a 19.2 x 23-cm area
- Each pixel is 100 μm, largest pixel size of the available FFDM systems

Can use in association with CAD systems
**7. Technologies for FFDM – Indirect Capture**

Photostimulable Phosphor Plates (Computed Radiography)
(Fuji – not approved for Mammography yet)

When x-rays are absorbed, electronic charges are stored proportionally in "traps" in the phosphor.

**7. Technologies for FFDM – Direct Capture**

Flat-Panel a-Se Array (Lorad Selenia, Hologic)

- a-Se, a good photoconductor is deposited directly onto the a-Si TFT substrate enabling direct capture.
- The a-Se detector directly converts x-rays to electron-hole pairs.
- The a-Si TFT converts the electron-hole pairs to electronic signal.
- 25 x 29-cm field of view, the largest among all systems.
- Accommodates all breast sizes.
- Pixel size is 70 mm.

Flat-Panel a-Se Array (Lorad Selenia, Hologic)

Http://www.hologic.com/wh/digisel.htm

**7. Technologies for FFDM – Direct Capture**

Flat-Panel a-Se Array (Mammomat Novation, Siemens)

- Approved recently.
- 24 x 29-cm field of view.
- Accommodates all breast sizes.

Flat-Panel a-Se Array (Mammomat Novation, Siemens)

Http://www.medical.siemens.com
7. Technologies for FFDM

Radiology 2005;234,353

7. FFDM – Radiation Dose

- DS system
  - Contrast mode: 219 mrad or 2.19 mGy
  - Standard mode: 109 mrad or 1.09 mGy (28 kV, 48 mAs)
  - Dose mode: 89.2 mrad or 0.892 mGy

- Film-screen
  - Standard mode: 151 mrad or 1.51 mGy (28 kV, 65 mAs)

7. Storage of Digital Images

- Signals are digitized into one of $2^n$ intensity levels within each pixel, where $n$ is the number of bits
- If 12 bits, 4,096 signal values, if 14 bits, 16,384 signal values
- A digital detector of $N$ pixels requires $2N$ bytes of storage (2 bytes per pixel)

<table>
<thead>
<tr>
<th>Manufacturer and Model</th>
<th>Image Matrix (pixels)</th>
<th>Image Size (megapixels)</th>
<th>Storage Requirement (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Senographe 2000D</td>
<td>$1,020 \times 2,304$</td>
<td>4.4</td>
<td>8.8</td>
</tr>
<tr>
<td>Fischione Sens丞</td>
<td>$4,096 \times 5,025$</td>
<td>23.0</td>
<td>46.1</td>
</tr>
<tr>
<td>Hologic Selenia</td>
<td>$5,328 \times 6,096$</td>
<td>13.6</td>
<td>27.2</td>
</tr>
<tr>
<td>Full CR</td>
<td>$1,279 \times 2,379$</td>
<td>4.2</td>
<td>9.4</td>
</tr>
<tr>
<td>Hologic CCD array</td>
<td>$2,364 \times 2,044$</td>
<td>7.0</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>$4,596 \times 6,000$</td>
<td>27.0</td>
<td>54.0</td>
</tr>
</tbody>
</table>

*For a typical four-image screening examination.
Currently not approved by the FDA.
No longer commercially available.

7. Display of Digital Images

Radiographics 2004;24,1757
7. Economics of FFDM

- SFM systems cost well under $100,000
- FFDM systems cost in the range of $300,000 - $450,000
- One attractive reason for centers to “go digital” is the higher reimbursement rates approved by Medicare in 2003
  - SFM - $83.03 (2008)
  - FFDM - $133.69 (2008)

7. Expected Benefits of FFDM

- The costs of FFDM systems should be compared along with the inherent benefits of the digital technology prior to the purchase:
  - Reduced recall rates
  - Increased patient throughput
  - Increased early detection of breast cancer
  - Decreased false-negative biopsy results
  - Decreasing film and processing costs
  - Increasing the caseload of each mammography room

7. Clinical Trials and Phantom Studies

- Larger screening study screened 49,500 women
- Digital Mammographic Imaging Screening Trial (DMIST), funded by NCI and conducted by ACRIN (http://www.acrin.org/6652_protocol.html)

7. Advantages and Disadvantages

- Advantages
  - Optimize post-processing of images
  - Permit computer-aided detection to improve the detection of lesions
  - Storage of images easier

- Disadvantages
  - Image display and system cost
  - Limiting spatial resolution is inferior to film, 10 lp/mm vs. 20 lp/mm
Take Home Points

- Quality Assurance important and regulated by MQSA in mammography
  - Radiologist oversees program
  - Physicist and technologist responsibilities
  - Phantom – 4 fibers, 3 masses, 3 specks should be seen
  - Stereotactic units used for breast biopsy, use geometry to calculate lesion location
  - Digital mammography becoming common
    - GE, Fischer, Lorad/Hologic, Siemens approved by FDA
  - Indirect and Direct systems used
  - CAD used in association with digital systems
  - Advantages and disadvantages

8. Quality Assurance & Quality Control

- Regulations mandated by the MQSA of 1992 specify the operational and technical requirements necessary to perform mammography in the USA
  - For a facility to perform mammography legally under MQSA, it must be certified and accredited (ACR or some states)

8. Radiologist Responsibilities

- Responsibilities include
  - Ensuring that technologists are appropriately trained in mammography and perform required quality assurance measurements
  - Providing feedback to the technologists regarding aspects of clinical performance and QC issues
8. Radiologist Responsibilities

- Responsibilities include:
  - Having a qualified medical physicist perform the necessary tests and administer the QC program
  - Ultimate responsibility for mammography quality assurance rests with the radiologist in charge of the mammography practice
  - The medical physicist and technologist are responsible for the QC tests

8. Mammography phantom

- Is a test object that simulates the radiographic characteristics of compressed breast tissues, and contains components that model breast disease and cancer in the phantom image
- It is intended to mimic the attenuation characteristics of a "standard breast" of 4.2-cm compressed breast thickness of 50% adipose and 50% glandular tissue composition

- 6 nylon fibers, 5 simulated calcification groups, 5 low contrast disks that simulate masses
- To pass the MQSA quality standards, at least 4 fibers, 3 calcification groups and 3 masses must be clearly visible (with no obvious artifacts) at an average glandular dose of less than 3 mGy

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# 8. Technologist Quality Control

## Table 8-8. Periodic Tests Performed by the Quality Control (QC) Technologist

<table>
<thead>
<tr>
<th>Test and Frequency</th>
<th>Requirements for Acceptable Operation</th>
<th>Documentation Guidance</th>
<th>Timing of Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor base fog density — daily</td>
<td>≤ ±0.03 OD of established operating level</td>
<td>QC records and charts for last 12 months; QC films for 30 days</td>
<td>Before any further clinical films are processed</td>
</tr>
<tr>
<td>Processor mid-density (MD) value — daily</td>
<td>Within ±0.15 OD of established operating level for MD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processor density difference (DD) value — daily</td>
<td>Within ±0.15 OD of established operating level for DD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


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1. The average glandular dose for a 4.2 cm compressed breast is about:
   - A. 1.3 mGy (130 mrad)
   - B. 1.7 mGy (170 mrad)
   - C. 3.0 mGy (300 mrad)
   - D. 120 mR
   - E. 170 mR
1. In mammography, a fiber interspaced grid is preferred over aluminum because it:
   (A) Reduces the dose
   (B) Improves resolution
   (C) Removes more scatter
   (D) Reduces image mottle
   (E) Improves contrast

1. Ideally, the AEC (phototimer) sensor in mammography should be placed:
   A. As close to the chest wall as possible.
   B. Under the densest portion of the breast.
   C. Under the least dense portion of the breast.
   D. Under the most anterior portion of the breast.
   E. In the center of the breast.

1. Which grid would be the best choice for use as a stationary grid in mammography?
   A. 44 lines/cm, 5:1 ratio
   B. 44 lines/cm, 12:1 ratio
   C. 80 lines/cm, 5:1 ratio
   D. 80 lines/cm, 12:1 ratio
   E. Any of the above, as long as they are made of carbon fiber

1. Which of the following is not true? Vigorous compression in mammography reduces:
   A. Patient dose.
   B. Scatter.
   C. Motion unsharpness.
   D. Subject contrast.
Question

1. Magnification radiography using current imaging equipment:
   - (A) Reduces the entrance skin exposure
   - (B) Improves the definition of fine detail
   - (C) Requires large focal spots larger than 0.3 mm
   - (D) Reduces film density
   - (E) Requires moving the film further from the tube