Croatia and the EU:
Together
Against Cancer

IMPROVEMENT OF QUALITY OF THE NATIONAL CANCER SCREENING PROGRAMMES IMPLEMENTATION (CRO SCREENING)

MINISTRY OF HEALTH OF THE REPUBLIC OF LITHUANIA
NCI
LITHUANIAN UNIVERSITY OF HEALTH SCIENCES
CPVA
NIJZ Nacionalni institut za javno zdravje
Ministry of Health
HZJZ HRVATSKI ZAVOD ZA JAVNO ZDRAVSTVO

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Quality control implementation and breast radiation protection in BC screening in Croatia

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Implementacija kontrole kvalitete i zaštite od zračenja u NPP u Hrvatskoj

Introduction

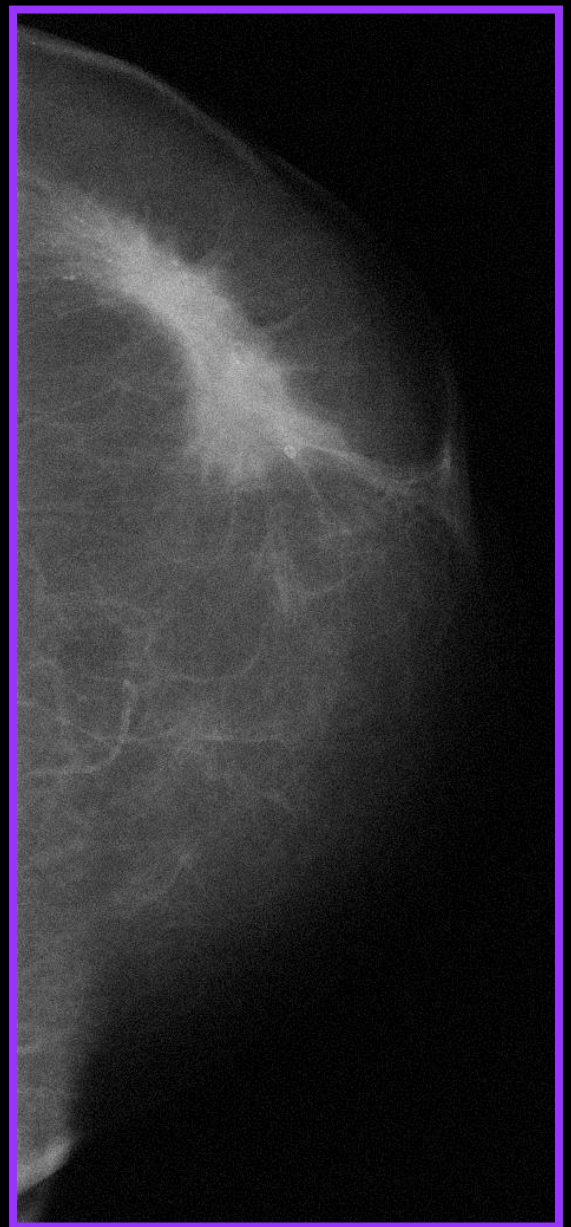
- X-ray mammography is a reliable method of detecting breast cancer
- The method of choice for breast cancer screening programs in many developed countries
- The best possible **image quality** should be achieved through optimization of all variable imaging parameters – the importance of QA/QC
- **breast radiation dose** should be ***ALARA*** - image quality and radiation exposure **should be balanced**

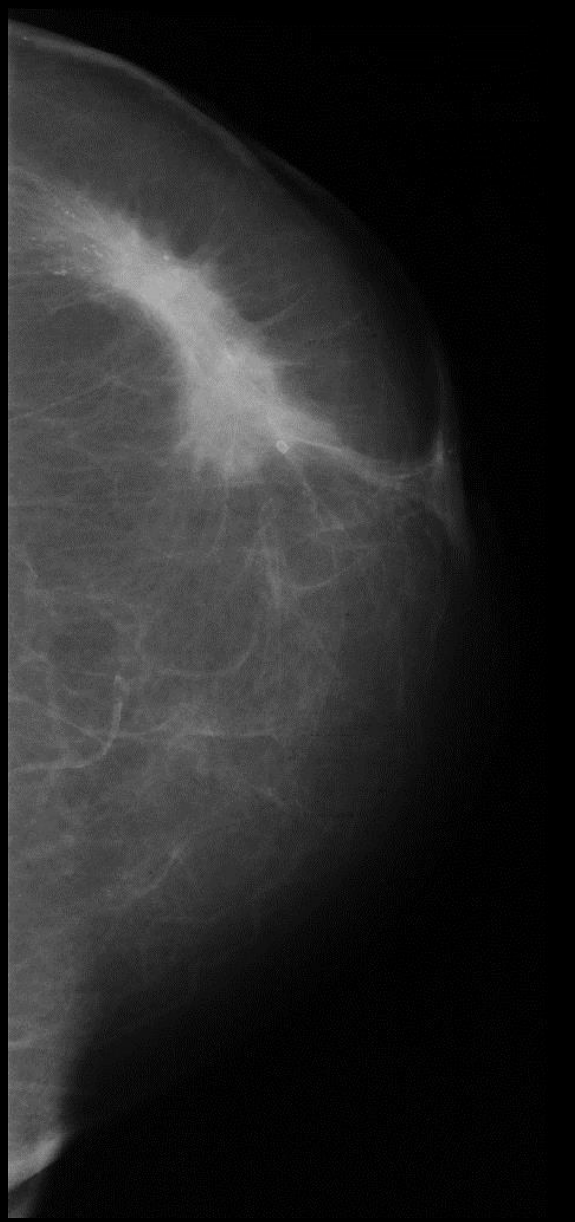
Uvod

- Mamografija je pouzdana metoda pronalaženja karcinoma dojke
- Metoda izbora za nacionalne preventivne programe u razvijenim zemljama
- Treba težiti najboljoj mogućoj slici kroz optimizaciju svih parametara slike – bitna uporaba kontrole kvalitete
- **Doza na dojke** treba biti vođena **ALARA** principom – ravnoteža između doze i kvalitete snimke

ALARA – As Low As Reasonably Achiavable

ALARA

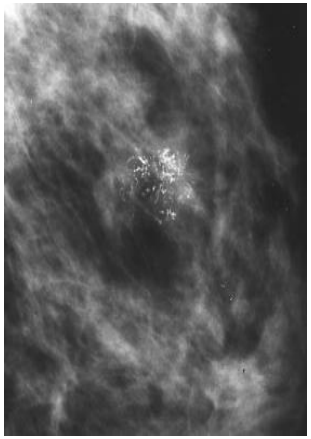


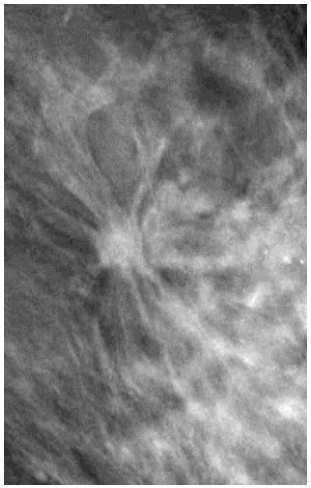


Mammography image quality requirements

- High spatial resolution
- High contrast
- High SNR

..are necessary to detect the signs of early breast cancer





Potrebna kvaliteta mamograma

- Visoka prostorna rezolucija
- Visoki kontrast
- Visoki odnos signal-šum

..su potrebni kako bi se pronašli rani znaci karcinoma

Radiosensitivity of the breast

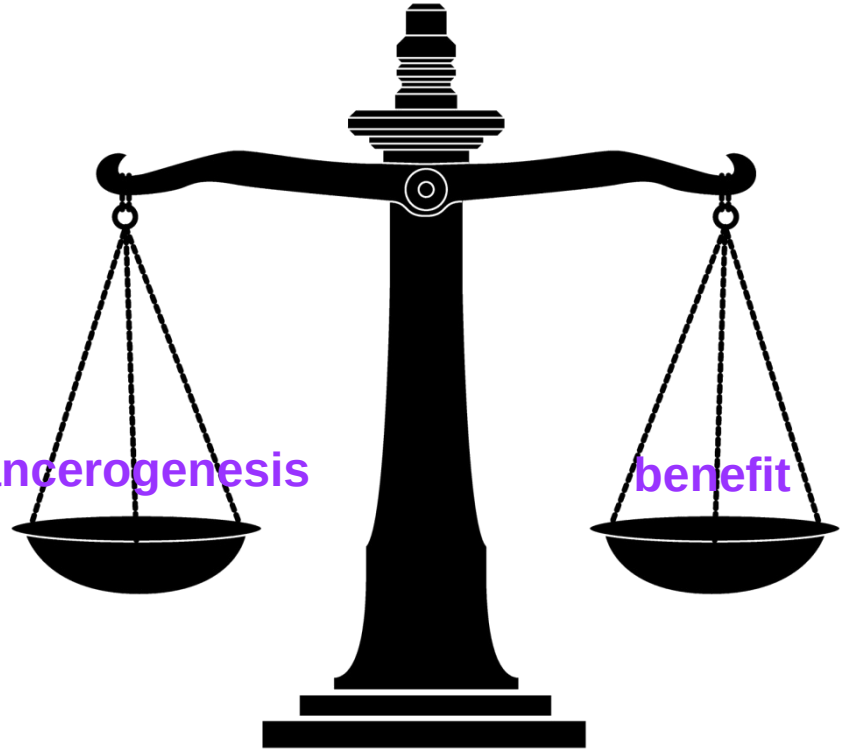
Radiation induced cancerogenesis

- Glandular breast tissue – high radiosensitivity
  - stochastic type - linear dose–response relationship
  - no dose threshold
  - increases considerably with younger age
    - BC incidence increases in young women
    - glandular tissue amount larger in young age
- Fat not radiosensitive!

Osjetljivost dojke na zračenje

Zračenjem inducirana kancerogeneza

- Visoka osjetljivost na zračenje parenhima dojke
  - Stohastički tip – linearni odnos doze i odgovora
  - Nema praga nastajanja
  - Više u mlađoj dobi:
    - Ca češće induciran u mlađoj dobi
    - Više parnhima u mlađih žena
- Masno tkivo nije radiosenzitivno

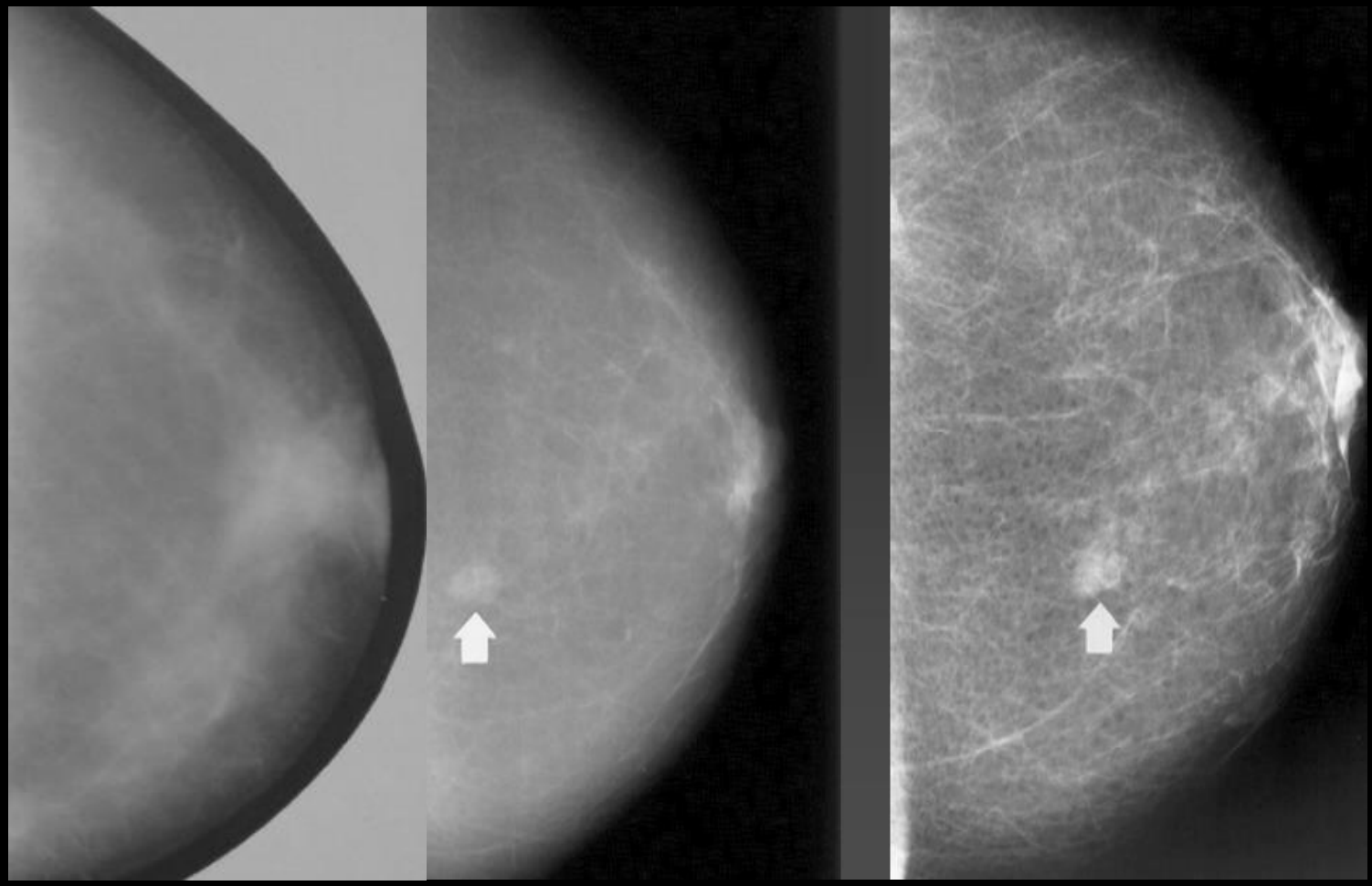

cancerogenesis
benefit

The history of mammography doses

- 1930s - attempts to image the breast with X-rays with **70 kVp**
- 1950s – direct-exposure films - low kVp, high mAs, no grids – **very high doses**
- 1960s – **Xero-mammography** – high contrast, good sharpness, doses lower
- 1970s – **SFM** – acceptable image quality, dose 20 mGy/image
- 1980s – **rare earth screen FM**, **AEC**- doses 5-10 mGy/image
- 2000s – **FFDM** - dose <1 mGy/image

Mamografske doze kroz povijest

- 30te – pokušaji RTG snimanja dojki s **70 kVp**
- 50te – izravno eksponirani filmovi s niskim kVp, visokim mAs, bez rešetke – **vrlo visoke doze**
- 60te – **Xero-mamografija** – bolji kontrast i oštrina, niže doze
- 70te – **folija-film** – prihvatljiva kvaliteta, doza 20 mGy
- 80te – **folije rijetkih zemalja**, **AEC**- doze 5-10 mGy
- 2000te – **DM** - doza<1 mGy



1960 1975 2010

Factors influencing radiation burden in a screening mammography programme

- Oganization dependent
- **Equipment dependent**
- **Radiographic technique dependent**

Čimbenici koji utječu na radijacijsko opterećenje u screening programu

- Organizacijski
- **Oprema**
- **Radiograferski tehnološki**

Radiation burden

Equipment dependent

- The age and quality of MG machines
- The technology: SFM vs CR vs FFD
  - The films and cassettes (sensitivity, green vs blue), dedicated processors, dedicated view-boxes
- The maintenance of equipment: x-ray tubes, AEC, film processors
- QA-QC implementation

Opterećenje zračenjem

Ovisno o opremi:

- Starost i kakvoća uređaja za mamografiju
- Tehnologija: film vs CR vs DM
  - Filmovi i kazete (osjetljivost, tip), dedicirane komore i negatoskopi
- Održavanje (RTG cijevi, AEC, komore)
- Kontrola kvalitete

Radiation burden

Radiographic technique dependent:

- Grid use
- Large breast Bucky
- Breast positioning
  - Angle
  - Compression
  - AEC position
- Exposure parameters
  - kVp
  - AEC vs manual
  - AEC – mAs only vs mAs + kVp
- Rejection/retake policy
- Fast vs slow film processing

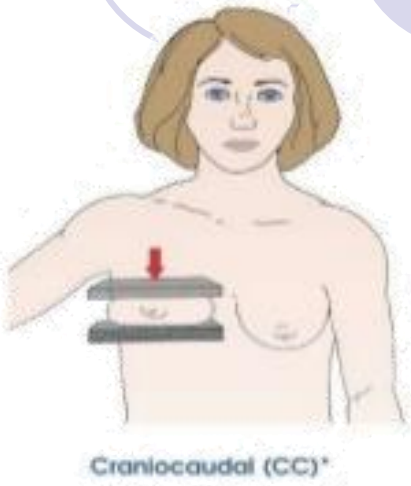
Opterećenje zračenjem

Ovisno o tehnici snimanja:

- Uporaba rešetke
- Bucky za velike dojke
- Pozicioniranje dojke
  - Kut
  - Kompresija
  - Pozicioniranje AEC
- Parametri ekspozicije
  - kV
  - AEC ili ručno
  - AEC (poluautomatsko ili automatsko)
- Stopa povrata snimaka
- Brzo/sporo razvijanje filma

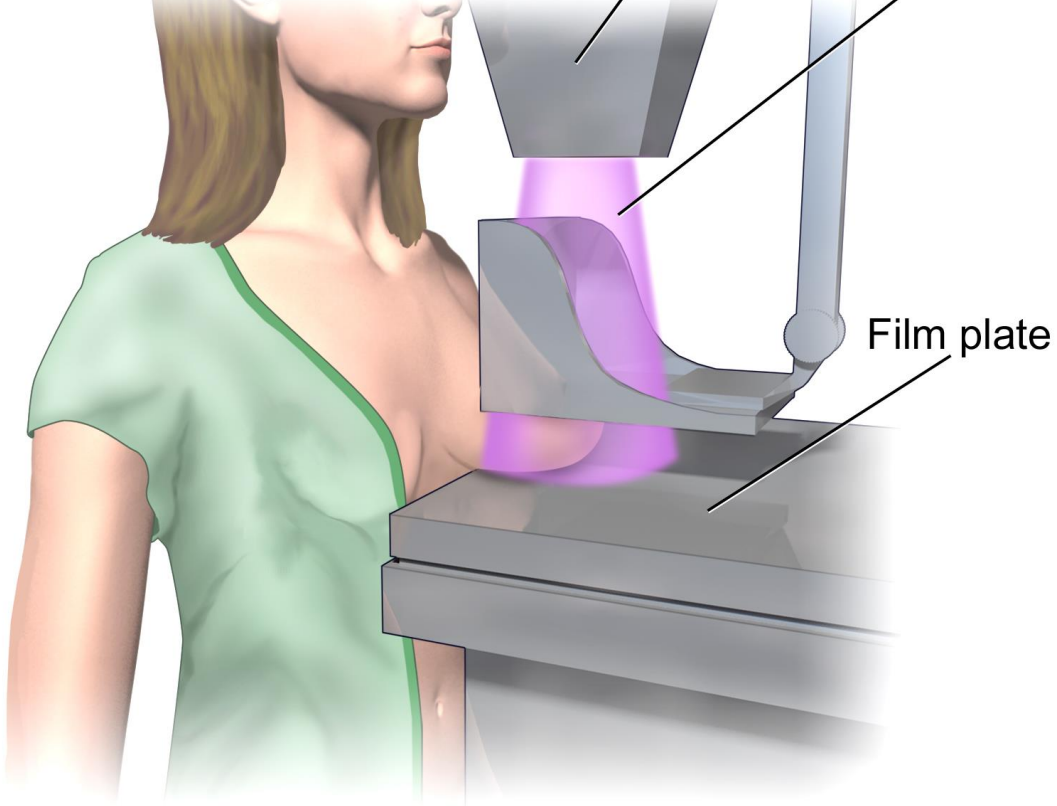
Breast positioning

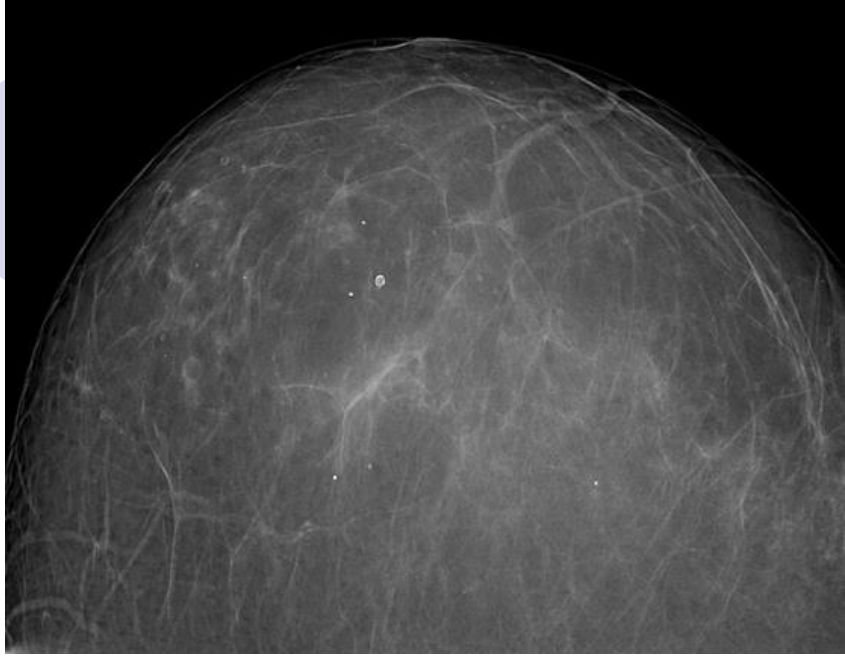
- 2 projections:
  - Craniocaudal(CC)
  - Mediolateral oblique (MLO) 45-60dg (higher dose)



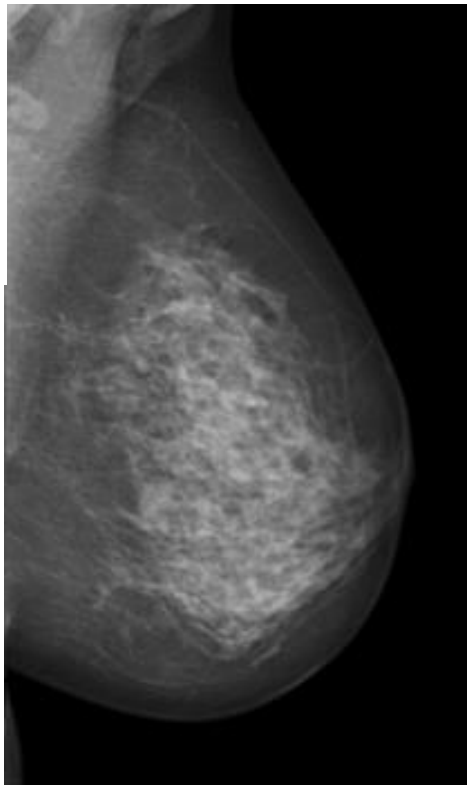
Pozicioniranje dojke

- 2 projekcije:
  - Kraniokaudalna (CC)
  - Mediolateralna kosa (MLO) 45-60st (viša doza)





Mammogram



Breast compression

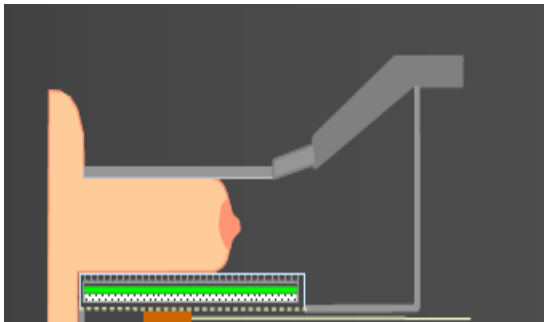
INCREASES IMAGE QUALITY

- *Increases sharpness:*
  - *Immobilization of the breast (less motion blur)*
  - *decrease of geometric blur (focal spot blur) & exposure time*
  - *decrease of superimposition by spread the glandular breast tissue onto larger area of film*
- *Increases contrast* through
  - *Reduction of scatter by decrease of breast thickness to 3-8 cm*
  - *Evens out breast thickness, evens out penetration of anterior and dosal parts of the breast*
  - *incompressible tumor emerge by its density*

Kompresija dojke

POVEĆAVA KVALITETU SNIMKE

- *Poboljšava oštrinu:*
  - *Onemogućava micanje tijekom snimanja*
  - *Smanjuje geometrijsko zamućenje i vrijeme ekspozicije*
  - *Smanjuje superpoziciju razmicanjem tkiva preko veće površine filma*
- *Povećava kontrast:*
  - *Smanjenjem rasapnog zračenja kod debljine dojke 3-8 cm*
  - *Ujednačava debljinu dojki i penetraciju RTG zraka*
  - *Nekompresibilni tumor dolazi do izražaja.*



Breast compression

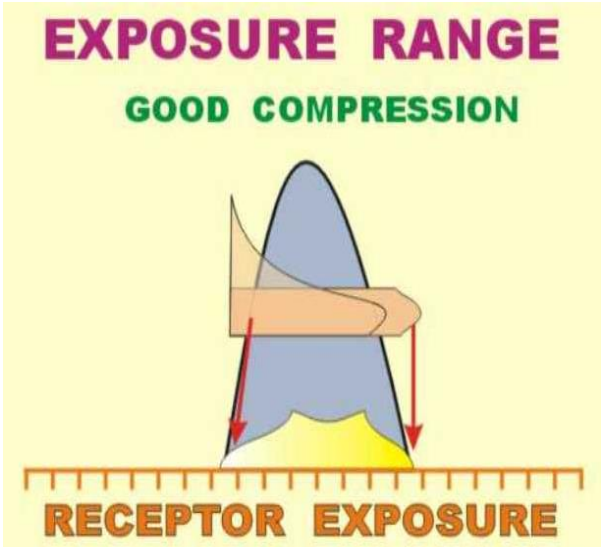
DECREASES THE RADIATION DOSE

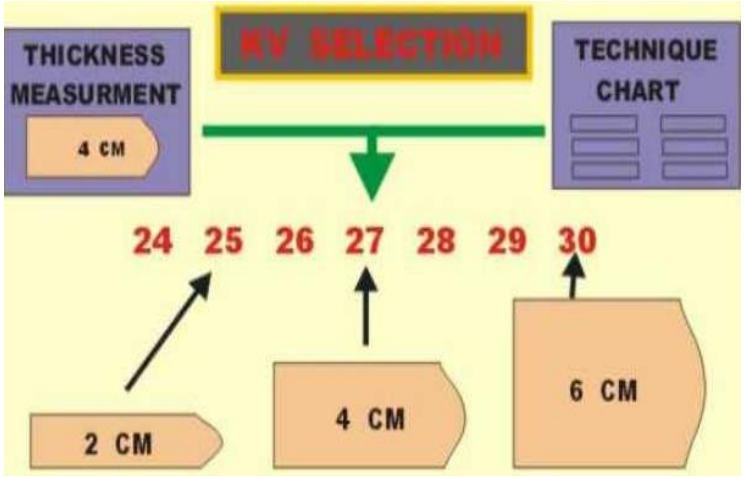
- *Better penetration with lower kVp – decrease of exposure (mAs) – **lower radiation dose***

Kompresija dojke

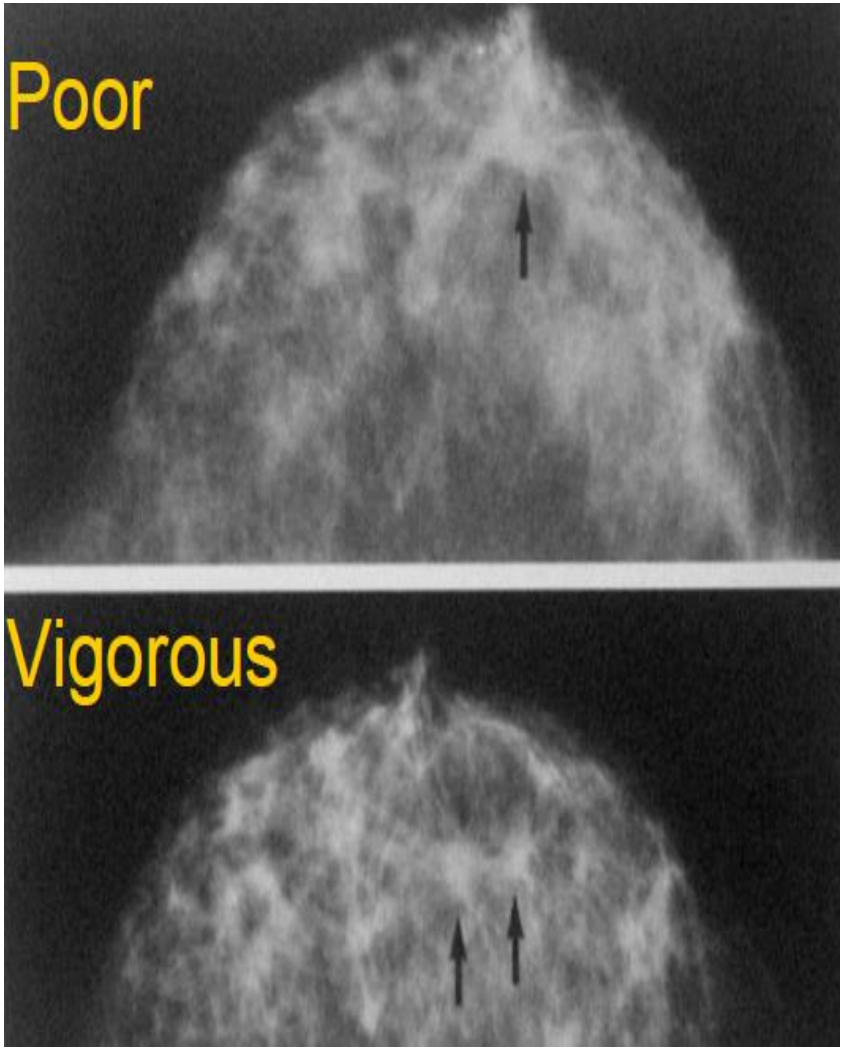
SMANJUJE DOZU OZRAČIVANJA

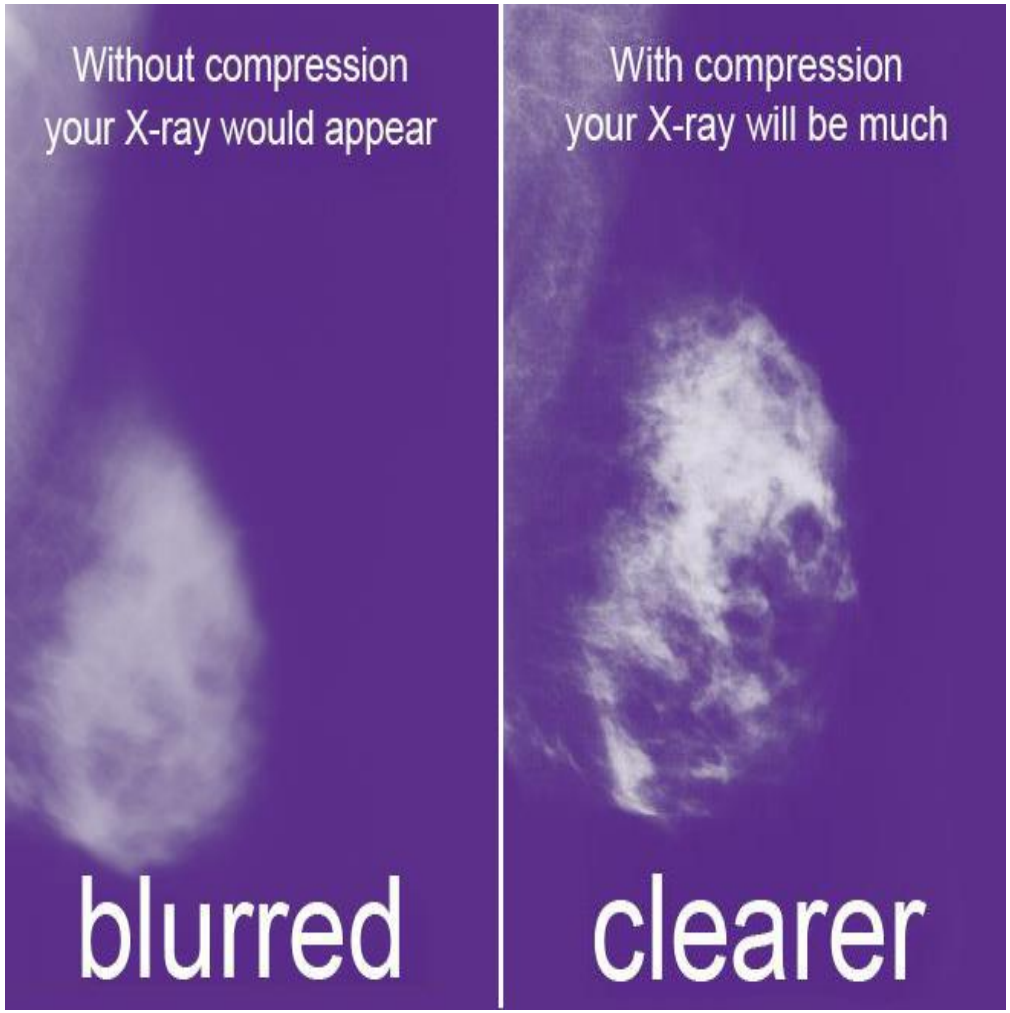
- *Bolja penetracija s manje kVp – manja doza*





Breast compression and image quality
Kompresije dojke i kvaliteta snimke





Breast compression and dose

- **Breast compression** (and positioning) is one of the the most important factor influencing breast dose and image quality
  - Compressed breast thickness 45 mm vs 40 mm
    - 20% decrease of AGD
  - Compressed breast thickness 80 mm vs 40 mm
    - 4× decrease of AGD

Kompresija dojke i doza

- **Kompresija dojke** (i pozicioniranje) je jedan od najbitniji čimbenika koji utječe na dozu i kvalitetu snimke
  - Debljina komprimiranog tkiv 45 vs 40mm
    - Smanjenje AGD 20%
  - 80 mm vs 40 mm
    - Smanjenje AGD4×

Compressed Breast	Entrance Exposure	Mean Glandular Dose
2 cm	260 mR	0.69 mGy
4 cm	1080 mR	1.79 mGy
6 cm	1450 mR	2.37 mGy

Kako znaš da sam bila na mamografiji danas?

Breast compresion

- Advise women before MG of the importance of proper compression
- Inform woman when compression starts
- Communicate with women whether can tolerate more force
- **minimal 11 kp, desirable 13-20 kp**
- QC of compression device
  - Check of integrity of compressor
  - Must remain parallel during compression
  - Compression force display
  - Automatic release after exposure

Breast compresion

- Objasniti ženama važnost dobre kompresije
- Upozoriti ženu kad će početi kompresija
- Pitati ženu može li izdržati jaču kompresiju
- **Najmanje 11 kp, poželjno 13-20 kp**
- Kontrola kvalitete kompresijskog tubusa:
  - Provjeriti očuvanost tubusa
  - Mora se kretati paralelno s buckyjem
  - Prikaz sile kompresije
  - Automatsko otpuštanje nakon ekspozicije

Mammograhams (Mammogram cookies)
http://www.grouprecipes.com/137043/mammo-grahams.html

Exposure parameters - kVp

- **Low kVp**
- *photoelectric absorption*
- low penetrability
- higher breast radiation exposure are needed to penetrate the breast
- high absorbed doses

- **High kVp**
- *Compton scattering*
- high penetrability
- higher scatter – high-ratio grids necessary to preserve image contrast - unacceptable due to increase in radiation dose

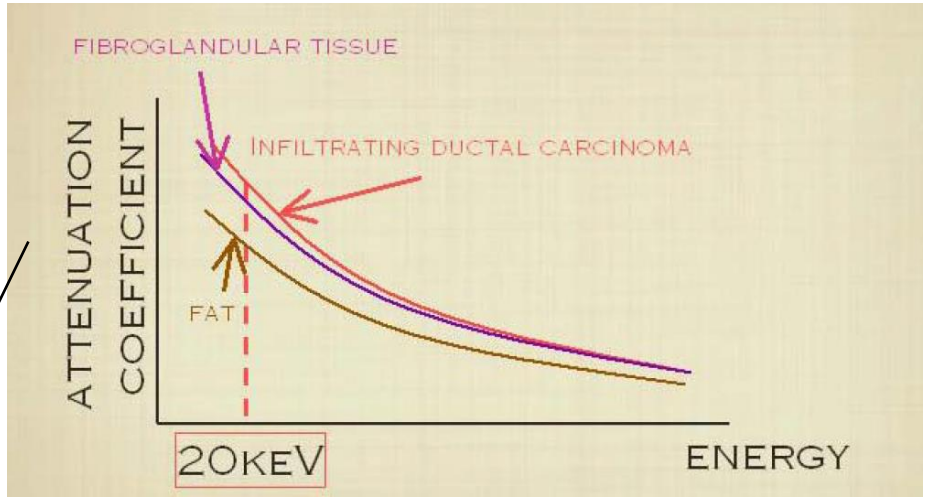
Parametri ekspozicije-napon

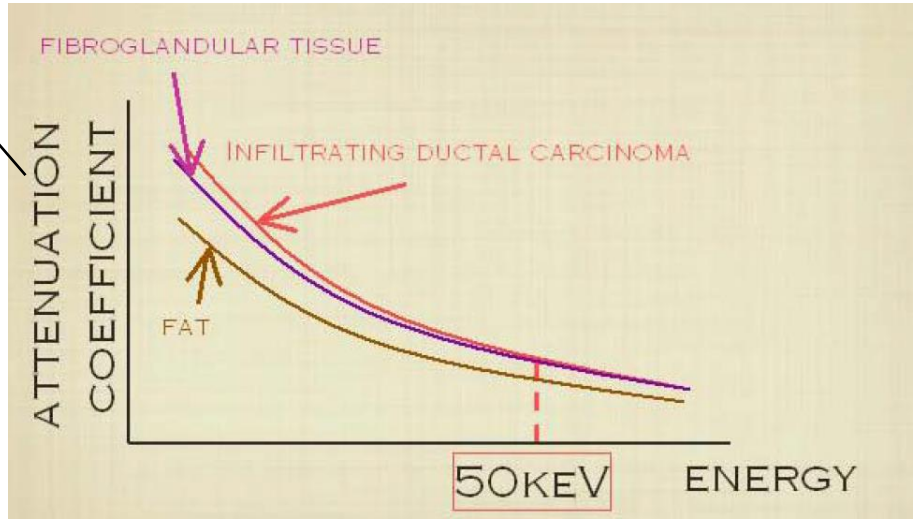
- **Niski napon (kVp)**
- *Fotoelektronska apsorpcija*
- Niska prodornost
- Potrebna veća doza da se probije tkivo
- Više apsorbirane doze

- **Visoki napon (kVp)**
- *Rasapno zračenje*
- Dobra prodornost
- Puno rasapa – potrebne rešetke visokog omjera kako bi se očuvao kontrast (razlučivost) – neprihvatljivo povećajne doze

kVp

keV	Fat	Fibrous	Ca.
18	0.558	1.028	1.085
20	0.456	0.802	0.844
25	0.322	0.506	0.529
30	0.264	0.378	0.392
40	0.215	0.273	0.281
50	0.194	0.233	0.238
80	0.167	0.189	0.192
110	0.152	0.17	0.173





Uh, opet sam pretjerao s kilovoltima!

Optimal kVp in mammography

Balance between the need for penetration the glandular tissue **(dose)** and image quality **(contrast)**

- **Manual technique** needs experience of technologist:
  - breast size
  - breast composition
  - breast compressed thickness
- **AEC** needs
  - Proper postioning of AEC detector
  - Regular calibration – QC task

Optimalni napon u mamografiji

Ravnoteža između potrebe za penetracijom tkiva **(doza)** i kvalitete snimke **(kontrast)**

- **Ručne tehnike** – iskusan radiografer:
  - Veličina dojke
  - Denzitet parenhima dojke
  - Debljina nakon kompresije
- **Za AEC** je potrebno:
  - Pravilno pozicioniranje detektora/komore
  - Pravilnu kalibraciju (kontrola kvalitete)

Repat Rate

$$\text{Repeat Rate} = \frac{\#\ of\ repeated\ films}{total\ \#\ of\ films} \times 100$$

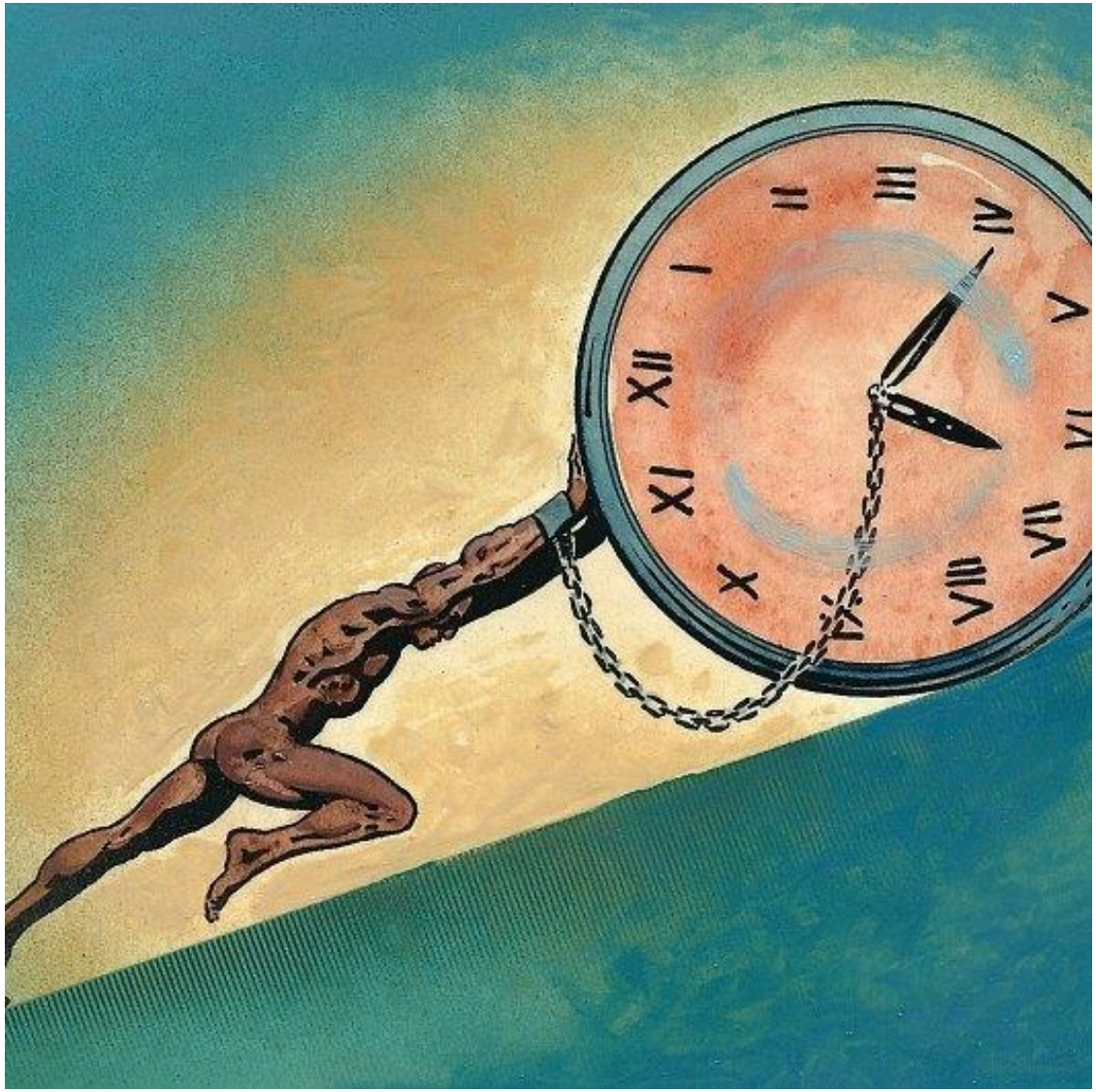
- Diagnostic Rx <5%
- Training Rx <10%
- Mx <2%
- QA

Retake policy

- Retake the film only when critical deffieciency occurs
- Do not retake films with non-critical positioning defficiencies (slight asymmetry, skin folds, pectoral muscle non-inclusion…)
- Communication radiologist - technologist – RT must be informed of the defficiencies in mammography technique, RTs with poor technique should be trained

Povrat snimaka

- Ponovno snimiti samo kad postoji značajni nedostatak
- Ne snimati ponovo kod ne jako bitnih nepravilnosti u pozicioniranju (manja asimetrija, nabor kože, nedostatni prikaz pektoralnog mišića)
- Komunikacija radiolog – tehnolog – edukacija tehnologa – odgovornost radiologa


XII
I
II
III
IV
V
VI
VII
VIII
IX
X
XI

AGD

- *Average/Mean glandular dose* (AGD) is the best representant of breast dose - glandular breast tissue has high radiosensitivity, while fat is not radiosensitive!
- good correlation between MGD and stochastic risk of cancerogenesis
- Indirect estimation
- 1-2mGy/image (0.7mSv)

- *Srednja žljezdana doza* (AGD) najbolje pokazuje visinu zračenja jer je samo žljezdani parenhim osjetljiv na zračenje, masno tkivo nije (ne razvija karcinom)
- Dobar odnos između AGD i stohastičkog rizika od kancerogeneze
- Mjeri se posrednom procjenom
- 1-2mGy/snimci (0.7mSv)

AGD (QC)

- AGD should be determined annually by a certified medical physicist
  - The AGD is obtained using the measured entrance skin exposure when imaging an ACR phantom that simulates a 4.2 cm breast with 50% glandularity
  - MQSA regulation (ACR) recommend AGD for a 4.2-cm thick breast should be less than 3 mGy/image for SFM with a grid

- AGD treba provjeravati godišnje (med.fizičari)
  - AGD se mjeri mjerenjem ulazne kožne doze kad se snima ACR fantom koji simulira dojku debljine 4.2cm s 50% žljezdanog tkiva
  - **ACR** preporuča AGD za 4.2-cm dojku manje od 3 mGy/slici za film mamografiju s rešetkom.

ACR – American College of Radiology

Breast dose calculator

DUKE UNIVERSITY AND DUKE MEDICINE
Radiation Safety Division
www.safety.duke.edu

Radiation Dose to the Breast From Mammography

Parameters for Computing Radiation Dose

This program uses parameterized data tables developed by Wu and colleagues (see "References" below) to compute radiation dose to the breast consequential to mammography. You can vary the thickness of the breast, the composition of the breast tissue and other variables to determine their effect on breast dose.

Complete the form below and click the **"Compute Dose"** button to calculate the radiation dose factor (millirads per roentgen of skin entrance exposure) for glandular breast tissue. Make sure you enter values for the parameters you wish to vary, consistent with the appropriate units. If you leave a field blank, a *default value* [shown in brackets] will be used. See "Notes" below for valid ranges for the parameters.

Enter kVp (kilovolts): 27 [25]
Enter Filtration Half-Value Layer (mm aluminum): 0.3 [.265]
Enter Thickness of Compressed Breast Tissue (cm): 3 [4]
Enter Glandular Fraction (0.0 - 1.0): .5 [.50]
Enter Skin Entrance Exposure (roentgens): 20 [variable]

Target / Filtration Combination (Select One):

◉ Molybdenum / Molybdenum ○ Molybdenum / Rhodium ○ Rhodium / Rhodium

All Done? Compute the Glandular Tissue Dose Factor: Compute Dose

http://vmw-oesoapps.duhs.duke.edu/radsafety/mammo_dose/default.asp

HOW THE CANCER INDUSTRY CONTROLS WOMEN*

*FACT: Breast cancer screening harms ten times as many women as it helps. See http://www.NewsTarget.com/020829.html

Mike Adams is the creator of the "Education, not Medication" program that seeks to help women prevent breast cancer.

Education
Not Medication


DID YOU KNOW...
When you are diagnosed with cancer, you are suddenly worth (a minimum of) $300,000 to the cancer industry.
Follow the $$$$$


Chemotherapy

Risk vs Benefit

- exposing 1 million 45-year-old women to AGD of 1 mGy may result in 2 excess breast cancer deaths
- two-view screening mammography (total AGD 3 mGy) results in excess risk of **6 cancers** / 1 million women
  - equivalent to
    - 200 km airplane travel
    - 3 cigarettes
- **2700-3000 carcinomas will be detected in 1 million screened women**

- Snimanje milijuna 45 godišnjih žena s AGD od 1mGy – 2 dodatna karcinoma
- MMG u dvije projekcije (AGD 3 mGy) – 6 karcinoma više na milijun žena
  - Kao i:
    - 200 km letenja avionom
    - 3 cigarete
- **2700-3000 karcinoma se pronaže na milijun snimanih žena**

Stochastic risk related to mamography (NRPB 2001)

Stohastički rizik vezan u MMG (NRPB 2001)

Examination	Lifetime additional risk of cancer per exam*
	Negligible Risk
Chest, teeth, arms & legs, hands & feet x-rays	Less than 1 in 1,000,000
	Minimal Risk
Skull, head, neck x-rays	1 in 1,000,000 to 1 in 100,000
	Very Low Risk
Hip, spine, abdomen, pelvis x-rays, CT head, breast mammography	1 in 100,000 to 1 in 10,000
	Low Risk
Kidney & bladder [IVU], Stomach – barium meal, CT chest, CT abdomen	1 in 10,000 to 1 in 1,000

Quality Control in Mx SFM

- **Daily**: Processor QC – sensitometry/densitometry, darkroom clean
- **Weekly**: screen cleaning, viewboxes
- **Monthly**: phantom images, visual check
- **Quarterly**: repeat analysis, hypo retention
- **Semianually**: compression, film/screen contact
- **Yearly**: collimation, resolution, AGD

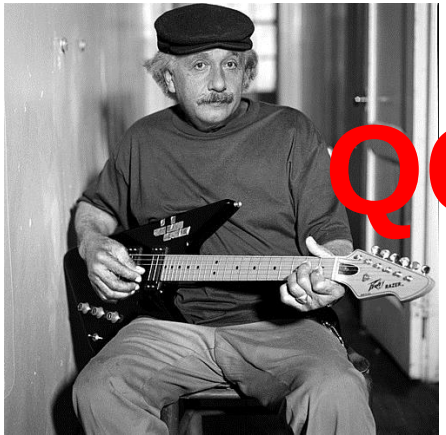
Kontrola kvalitete u film MMG

- **Dnevna**: QC komore – senzitometrija i denzitometrija, čišćene tamne komore
- **Tjedno**: čišćenje folija, negatoskopa
- **Mjesečno**: snimanje fantoma, vizualna provjera snimaka
- **Kvartalno**: analiza povrata snimaka, određivanje ostataka fiksira
- **Polugodišnje**: kompresija tubusa, kontakt filma i folije
- **Godišnje**: kolimacija, rezolucija, AGD


DIGITALNA MAMOGRAFIJA
ON
OFF
FILM MAMOGRAFIJA
ON
OFF

FFD pitfalls

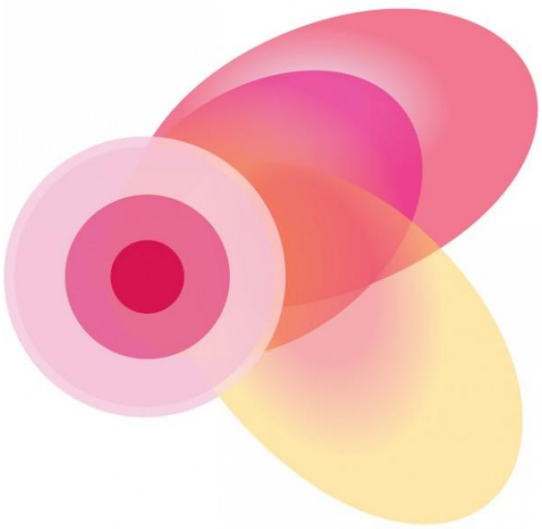
- High dose Mx seem normal on monitor
- Hard to notice high dose Mx with bare eye
- Medical phycisist



Zamke digitalne mamografije

- MMG s visokim dozama izgledaju normalno na monitoru
- Teško primjetiti golim okom – potrebna QC
- Medicinski fizičar

Breast radiation dose in mammography in Croatia



Doze zračenja dojki u mamografiji u Hrvatskoj

QC in Croatian screening programme

- Biannual visits by expert radiologists
- Assessment of:
  - Mx tract
  - Mx equipment
  - Staff behaviour
  - Image quality
  - RT knowledge and skill
  - Radiologists knowledge of BI-RADS lexicon

QC u hrvatskom screening programu

- Posjeti radiološkog eksperta 1x u 2g
- Ocjenjivanje:
  - MMG prostorija
  - MMG opreme
  - Ponašanje osoblja
  - Kakvoće snimaka
  - Poznavanje tehnike snimanja mamografera
  - Poznavanje BI-RADS deskriptora radiologa

Radiation burden factors

Organization dependent

- The age of population invited – 50-69 yo
- The genetics of exposed women – all women – non-selected
- Screening interval – 2 y
- One- vs two-view mammography

Čimbenici radijacijskog opterećenja

Organizacijski

- Dob – 50-69 g
- Čimbenici rizika – bez selekcije
- Interval snimanja – 2g
- Snimanje u dvije projekcije

Radiation burden factors

Equipment dependent

- The age and quality of MG machines >10 yrs
- The technology: SFM vs CR vs FFD
  - The films and cassettes (sensitivity, green vs blue), dedicated processors and viewboxes rarely available
- The maintenance of equipment: x-ray tubes, AEC average, film processors unsatisfactory
- QA-QC implemented partialy in<1/3 MUs

Čimbenici radijacijskog opterećenja

Oprema

- Starost i kakvoća opreme>10g
- Tehnologija: SFM vs CR vs DM
  - Filmovi i kazete, rijetko dostupni dedicirani negatoskopi i komore
- Održavanje opreme – RTG cijevi, AEC – osrednje, komora nedostatno
- QA-QC djelomice in<1/3 MUs

Radiation burden factors

Radiographic technique dependent

- Grid use is common
- Large breast Bucky lack in some MUs
- Breast positioning
  - Angle mainly 45, technique is average to poor in some MUs
  - Compression too low (7-11 kp)
  - AEC position . Good, no QC
- Exposure parameters
  - kVp
  - AEC vs manual
    - Some RTs are „AEC addicts” not able to do manual technique
- Rejection/retake policy – no repeat analysis in the majority of MUs
- Fast vs slow film processing

Čimbenici radijacijskog opterećenja

Radiograferska tehnika:

- Rešetka uobičajeno
- Bucky za velike dojke neke MJ nemaju
- Pozicioniranje dojki
  - Kut snimanja uglavnom 45 MLO, tehnika snimanja osrednja do loša u nekim MJ
  - Kompresij preslaba (7-11)
  - Položaj AEC – dobro, bez QC
- Exposure parameters
  - kVp
  - AEC vs manual
    - Neki tehnolozi ne znaju ručno eksponirati
    - Analiza ponavljanja snimaka – nepostojeća
- Brzo vs sporo razvijanje filma

Main MU imperfections

- Old and and outdated mammography equipment:
- Lack of medical physicists, mainly engaged in radiotherapy
- Critical lack of radiologists
- RTs of varying education level, skills and motivation
  - Positioning
  - Poor knowledge of FFD
  - NO QA-QC EXPERIENCE
- Many low-volume MUs in Healthcare Centres only 1-2 radiologists.
- Low number of cytologists with reliable experience to be a basis for basic work-up of positive pts
- Tissue diagnosis available only in larger regional centres
- Stereotactic biopsy available only in few institutions.

Osnovne manjkavosti MJ

- Zastarjela oprema
- Nedostatak mediciskih fizičara
- Značajan nedostatak radiologa
- Radiološki tehnolozi različitih razina znanja, vještina i motivacije:
  - pozicioniranje
  - Loše poznavanje DM
  - Bez iskustva u QC
- Mnoge MJ niskog protoka imaju 1-2 radiologa
- Premalo citologa radi pouzdane citološe dijagnoze pozitivnih pacijenata.
- PH verifikacija dostupna samo u većim regionalnim centrima.
- Stereo/Tomo biopsija dostupna samo u nekoliko bolnica u državi.

Corrective actions

- Immediately
  - Disengage MUs with low throughput, MG units >15 yrs and poor image quality
  - Continue QC audits systematically annualy
- Mid-term (6m)
  - RTs education (positioning, compression)
  - Consistent QA-QC system implementation
  - Measure MGDs in all MU's to prepare the Croatian DRLs
- Long-term (1-2 yrs)
  - Mammography equipment renewal and standardization, the role of tomosynthesis?
  - Rejection/retake policy control
  - Establish the role of 2nd radiologist as a primary image QC, feedback to RTs
  - Establish DRLs in Croatian NBCSP

Kako poboljšati?

- Žurno
  - Isključiti MJ s niskim protokom žena, uređajima starijim od 15g i lošom kvalitetom snimaka.
  - Nastaviti kontrolne nadzore u godišnjim intervalima
- Srednjeročno (6mj)
  - Edukacija mamografera (pozicioniranje, kompresija)
  - Implementacija kontrole i osiguranja kvalitete
  - Mjerenje AGD u svim MJ kako bi se dobile hrvatske
- Dugoročno (1-2 yrs)
  - Zanavljanje opreme, uključivanje tomosinteze u screening
  - Analiza vraćanja snimaka
  - Uloga drugog čitača u svrhu kontrole kvalitete i komunikacije s mamograferom
  - Edukacija citologa, patologa i radiologa radi sekundarne obrade
  - Uspostaviti DRL za Hrvatsku.

DRL – diagnostic reference levels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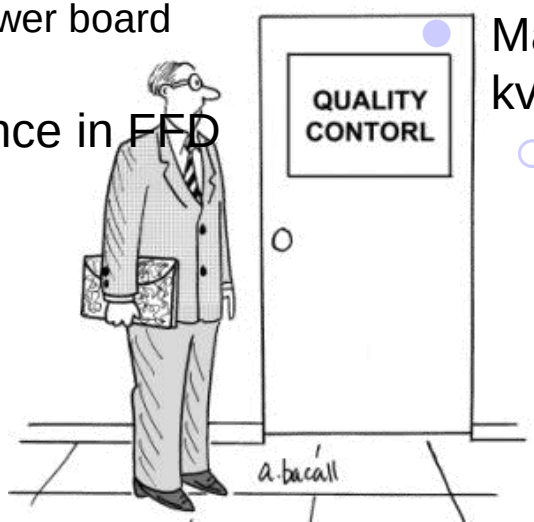
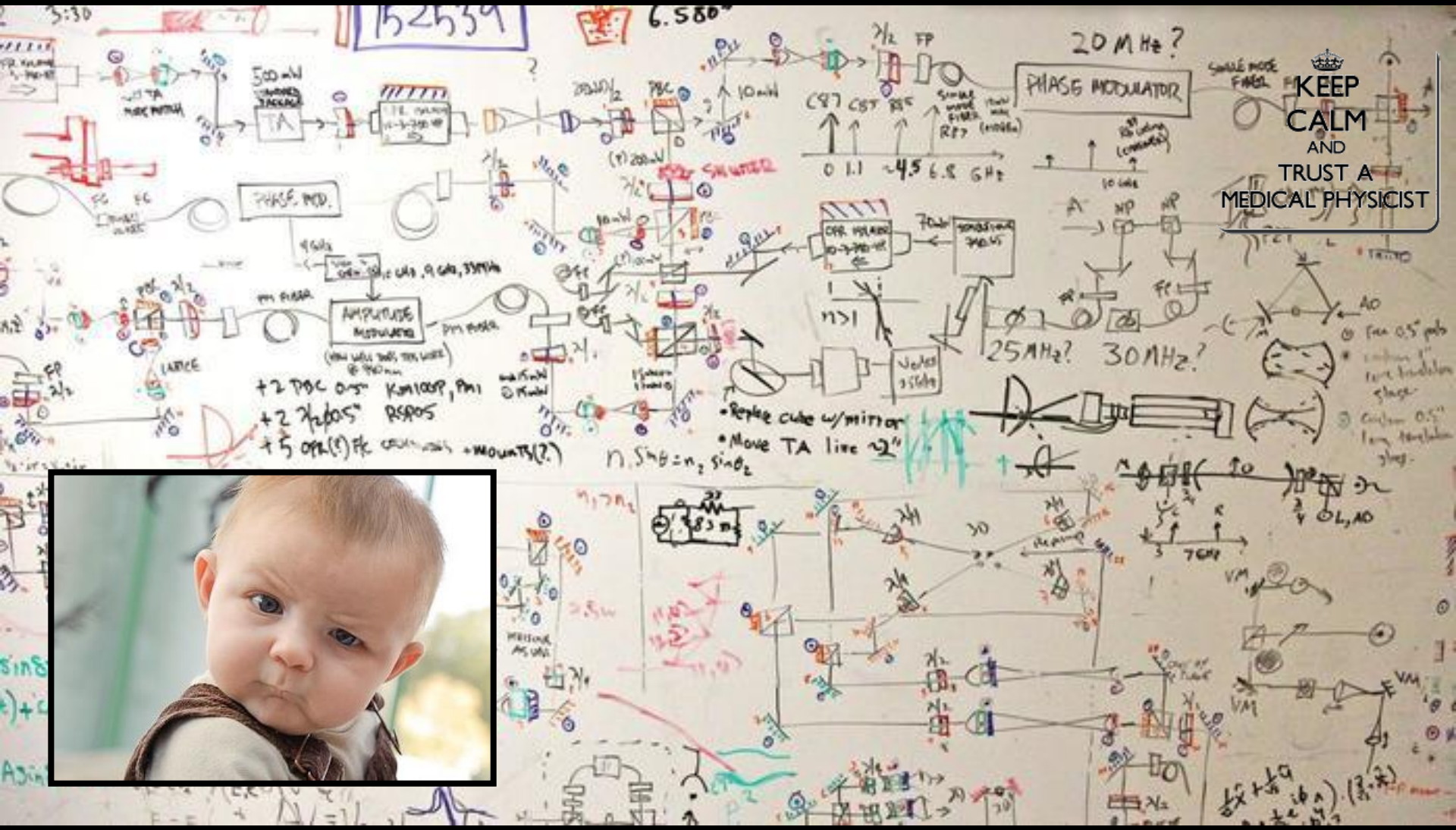
Main QC shortcomings

- High level of subjectivity
  - Objective measurments should be undertaken
    - Medical physicist should be involved
    - Additional QC equipment for reviewers
- Unequal standards for different reviewers
  - Education
  - more frequent reviewer board meetings.
- Low level of experience in FFD QC
  - Education

Osnovne manjkavosti QC

- Subjektivnost ocjene
  - Uvesti objektivna mjerenja u QC
    - Treba uključiti medicinskog fizičara
    - Dodatna oprema za QC
- Nejednaki standardi radioloških eksperata
  - Edukacija
  - Češći sastanci povjerenstva za praćenje i kontrolu kvalitete NPP
- Malo iskustva s kontrolom kvalitete u DM
  - Edukacija




KEEP
CALM
AND
TRUST A
MEDICAL PHYSICIST
PHASE MODULATOR
20 MHz ?
25MHz?
30MHz?