gruppoitalianoscreening mammografico

EDIZIONE VIRTUALE

CONVEGNO NAZIONALE
GISMa 2021
14-16 DICEMBRE 2021

SCREENING MAMMOGRAFICO: UNA QUESTIONE DI METODO

CORSO
TSRM / FISICI
14 DICEMBRE 2021

SERVIZIO SANITARIO REGIONALE
EMILIA-ROMAGNA
Azienda Unità Sanitaria Locale di Reggio Emilia
IRCCS Istituto in tecnologie avanzate e modelli assistenziali in oncologia

Compressione, dose e qualità (clinica) dell'immagine

Andrea Nitrosi

CONVEGNO NAZIONALE GISMa 2021
14-16 DICEMBRE 2021

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14 DICEMBRE 2021

Compression in mammography

Vajuhudeen, Z., Haouimi, A. Compression in mammography. Reference article, Radiopaedia.org. (accessed on 10 Dec 2021) https://doi.org/10.53347/rID-80054

In mammography, compression of the breast is performed to reduce its thickness. By doing so, the following benefits are achieved:

- improved subject contrast (by reducing scattered radiation)
- improved density uniformity
- improved visualization of breast tissue near chest wall (by spreading out superimposed anatomy
- decreased radiation dose
- decreased blurring (by reducing motion artifact)
- Compression is performed by the use of compression paddles, a component of the mammographic unit, which can vary in size and function.

https://radiopaedia.org/articles/compression-in-mammography#:~:text=The%20typical%20compression%20force%20used,between%2010%20and%2020%20Newtons.

Q: Compression force… how much it's enough ?

In x-ray mammography, it is well known that the flattening of the breast improves image quality and reduces absorbed dose (citare Amended 2014 (Resolution 39)* ACR–AAPM–SIIM PRACTICE PARAMETER FOR DETERMINANTS OF IMAGE QUALITY IN DIGITAL MAMMOGRAPHY).

In the Euref protocol is stated: "***The compression of the breast tissue should be firm but tolerable. There is no optimal value known for the force, but attention should be given to the applied compression and the accuracy of the indication***."

Mean glandular dose

Vajuhudeen, Z., Singh, S. Mean glandular dose. Reference article, Radiopaedia.org. (accessed on 10 Dec 2021) https://doi.org/10.53347/rID-79640

The **mean glandular dose (MGD)** is an estimate of the average absorbed dose to the glandular tissues of a breast during mammography. It is measured in Gray (Gy).

The most commonly accepted method of calculating the mean glandular dose is described by *Dance* et al (2000):

$$MGD = K * g * c * s$$

K = entrant surface air kerma

g = conversion factor for 50% glandular breast based on thickness and half-value layer

c = correction factor based on non-standard glandularity/thickness

s = correction factor based on non-molybdenum anode/filter combination

https://radiopaedia.org/articles/mean-glandular-dose

Q: DOSE… how much it's «ALARA» ?

In the Euref protocol Executive summary is stated: "A prerequisite for a successful screening project is that the mammograms contain sufficient diagnostic information to be able to detect breast cancer, **using as low a radiation dose as is reasonably achievable (ALARA).**"

Table 1.4: Dose levels for typical breasts simulated with PMMA

Thickness of PMMA (mm)	Equivalent breast thickness (mm)	Maximum average glandular dose to equivalent breasts (mGy)	
		Acceptable level	Achievable level
20	21	≤ 1.0	≤ 0.6
30	32	≤ 1.5	≤ 1.0
40	45	≤ 2.0	≤ 1.6
45	53	≤ 2.5	≤ 2.0
50	60	≤ 3.0	≤ 2.4
60	75	≤ 4.5	≤ 3.6
70	90	≤ 6.5	≤ 5.1

Radiation Protection Dosimetry (2018), pp. 1–13
doi:10.1093/rpd/ncy024

PHYSICAL CHARACTERISATION OF FOUR DIFFERENT COMMERCIAL DIGITAL BREAST TOMOSYNTHESIS SYSTEMS

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Received 24 October 2017; revised 27 December 2017; editorial decision 19 January 2018; accepted 25 January 2018

Table 2. Exposure parameters and average glandular doses evaluated for different PMMA thickness for the systems studied in DBT mode.

DBT system	Equivalent breast thickness (mm)	Anode/filter	kVp	mAs	AGD 3D	3D vs 2D AGD ratio
Dimensions	21	W/Al	26	30	0.77	1.42
	32	W/Al	28	31	0.91	1.21
	45	W/Al	30	37	1.14	1.18
	53	W/Al	31	46	1.52	1.49
	60	W/Al	33	47	1.80	1.18
	75	W/Al	36	59	2.58	1.41
	90	W/Al	42	55	3.21	1.57
Innovality ST	21	W/Al	27	27.8	0.91	1.75
	32	W/Al	29	26.4	0.93	1.24
	45	W/Al	31	30.0	1.18	1.20
	53	W/Al	32	36.7	1.53	1.36
	60	W/Al	33	40.8	1.87	1.52
	75	W/Al	36	45.0	2.42	1.28
	90	W/Al	37	56.0	3.05	1.34
Innovality HR	21	W/Al	27	32.9	1.08	2.07
	32	W/Al	29	41.9	1.48	1.98
	45	W/Al	31	58.2	2.28	2.33
	53	W/Al	32	71.5	2.97	2.64
	60	W/Al	33	77.4	3.54	2.88
	75	W/Al	35	83.2	4.24	2.25
	90	W/Al	37	99.0	4.48	1.96
SenoClaire	21	Mo/Mo	26	40.0	0.95	1.66
	32	Rh/Rh	29	33.0	1.03	1.28
	45	Rh/Rh	29	50.0	1.40	1.17
	53	Rh/Rh	29	56.0	1.51	0.91
	60	Rh/Rh	29	75.0	1.91	1.48
	75	Rh/Rh	31	83.0	2.52	1.20
	90	Rh/Rh	31	128.0	3.51	1.43
Pristina	21	Mo/Mo	26	23.1	0.60	0.95
	32	Mo/Mo	26	54.4	1.02	0.99
	45	Rh/Ag	34	28.2	1.22	0.95
	53	Rh/Ag	34	33.7	1.33	0.98
	60	Rh/Ag	34	41.1	1.50	0.98
	75	Rh/Ag	34	60.1	1.91	0.97
	90	Rh/Ag	34	90.7	2.56	0.97

DICOM Standard Status

C.8.31 Breast Projection Image Modules		
Prev	C.8 Modality Specific Modules	Next

«1» means MANDATORY

C.8.31 Breast Projection Image Modules

C.8.31.1 Enhanced Mammography Image Module

Table C.8.31-1 specifies the Attributes that identify and describe general information about the Enhanced Mammography Image Module.

Table C.8.31-1. Enhanced Mammography Image Module Attributes

Body Part Thickness	(0018,11A0)	1	The average thickness in mm of the body part examined when compressed, if compression has been applied during exposure.
Compression Force	(0018,11A2)	1	The compression force applied to the body part during exposure, measured in Newtons.
Paddle Description	(0018,11A4)	1	Description of the compression paddle, if compression was applied to the body part during exposure.
Exposure Control Mode	(0018,7060)	1	Type of exposure control Defined Terms: AUTOMATIC MANUAL
Organ Dose	(0040,0316)	1	Organ dose value measured in dGy representing the collective total for all acquired frames. ***Note*** *This may be an estimated value.*
Entrance Dose in mGy	(0040,8302)	1	Entrance dose value measured in mGy at the surface of the patient representing the collective total for all acquired frames. ***Note*** *This may be an estimated value based on assumptions about the patient's body size and habitus.*

https://dicom.nema.org/medical/dicom/2015c/output/chtml/part03/sect_C.8.31.html

Reggio Emilia's provincial breast diagnosis network

At the beginning (2012) 11 GE Senographe Essential units
(3 CESM + 3 DBT)

Today 10 GE Senographe Essential units + 1 Pristina
(4 CESM + 11 DBT)

Breast screening program

From 45 to 49 every year - from 50 to 74 every 2 years

Workload activity (2019)

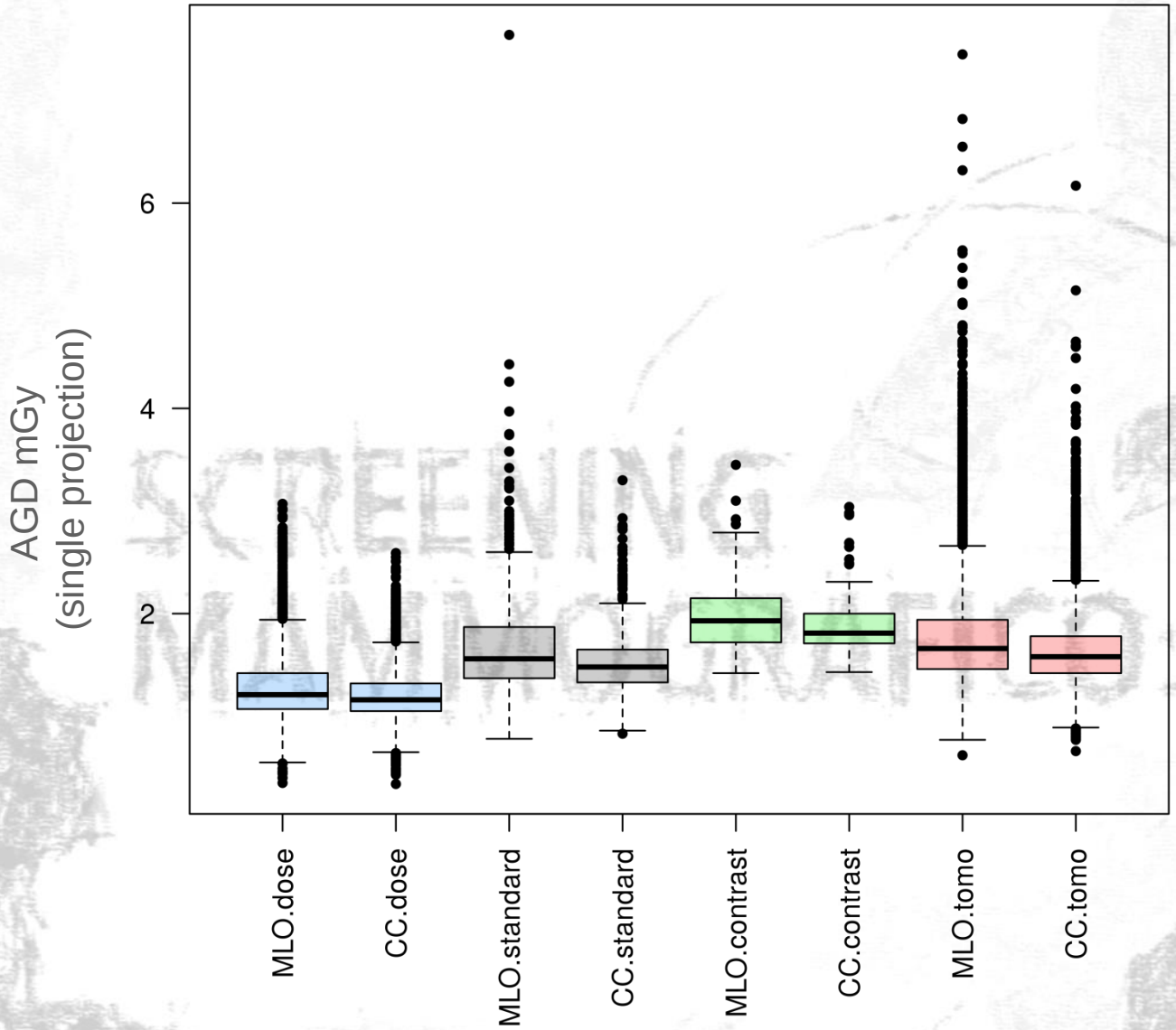
- about 49.937 women (+ 19.520 diagnostic exams)

Target population @ 2019 ~ 103.000 women
Screening program: adhesion ~79%

Radiographer → each workshift ~ 30 invited women

For 2D MX → three automatic exposure control modes with increasing dose levels are selectable ("DOSE", "STANDARD" and "CONTRAST")

AGD (mGy) vs AOP* mode



* 2D MG offers three automatic exposure control modes with increasing dose levels (“DOSE”, “STANDARD” and “CONTRAST”), while DBT uses a single mode (“TOMO”).

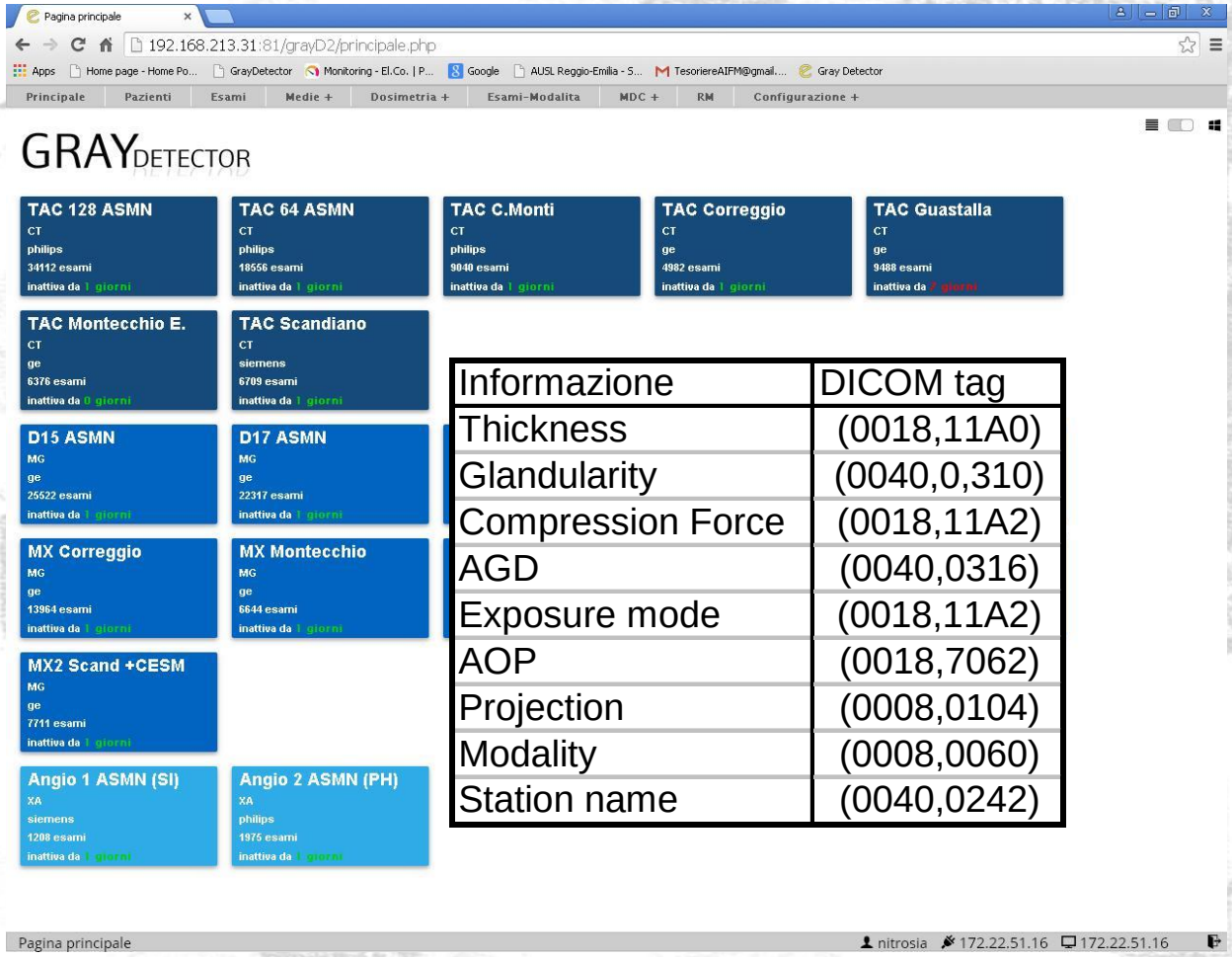
	AOP -->	DBT	2D		
		TOMO	DOSE	STANDARD	CONTRAST
AGD (mGy)	1st Qu.	1,44	1,06	1,35	1,72
	Median	**1,61**	**1,18**	**1,51**	**1,85**
	3rd Qu.	1,85	1,37	1,77	2,05
Thickness (mm)	1st Qu.	43	44	43	44
	Median	**53**	**53**	**54**	**52**
	3rd Qu.	61	62	63	59
Compression (daN)	1st Qu.	100	100	100	100
	Median	**110**	**110**	**110**	**110**
	3rd Qu.	130	130	130	120
Glandularity (%) (fibrogl./ fat))	1st Qu.	9	21	24	21
	Median	**20**	**40**	**43**	**39**
	3rd Qu.	29	65	67	67
	# projections	**15796**	**14196**	**1307**	**293**

Results reported are referred to 3949 women who performed
both 2D (CC-MLO) and DBT (CC+MLO) exams within a clinical trial

In 2014 Reggio Emilia Diagnostic Imaging Department (REDID) adopted a RIS-PACS integrated dose monitoring system called "Gray Detector"*. It records data from CT, mammography and angiographic examinations.

For mammography
AGD, compression,
thickness, glandularity,
automatic exposure control
(AOP mode),
are collected for
EACH PROJECTION*

@ Dec 10st 2021 more than
1,400,000 2D MX*
180,000 DBT*



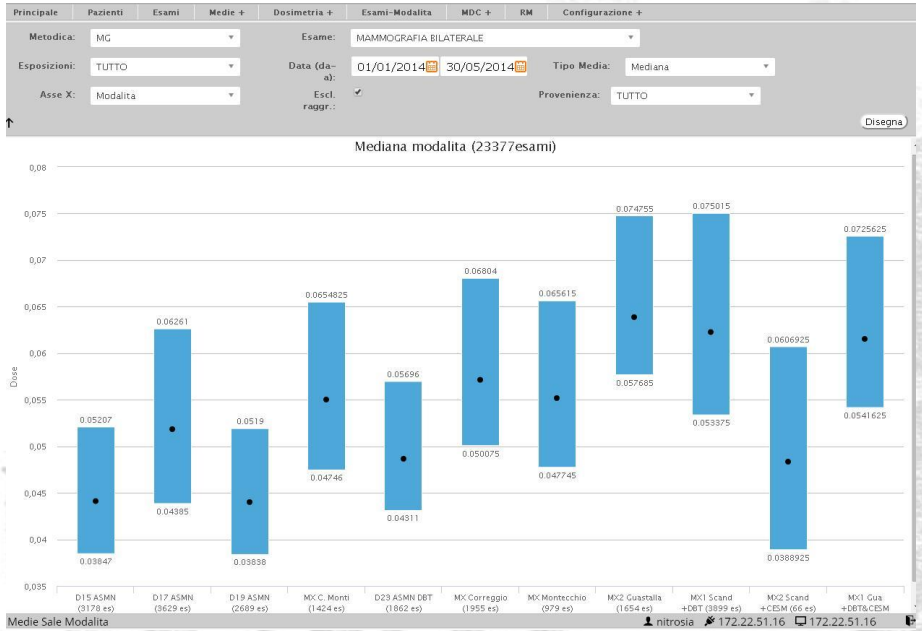
Informazione	DICOM tag
Thickness	(0018,11A0)
Glandularity	(0040,0,310)
Compression Force	(0018,11A2)
AGD	(0040,0316)
Exposure mode	(0018,11A2)
AOP	(0018,7062)
Projection	(0008,0104)
Modality	(0008,0060)
Station name	(0040,0242)

Patient dose management solution directly integrated in the RIS: "Gray Detector" software. Nitrosi A et al J Digit Imaging. 2014 Dec;27(6):786-93

Why AGD vary so much ?

PRE-Standardization

AGD dGy
(boxplot 25-75 percentile; dot = median)



AGD variation ~ 60%

Mammograhy unit

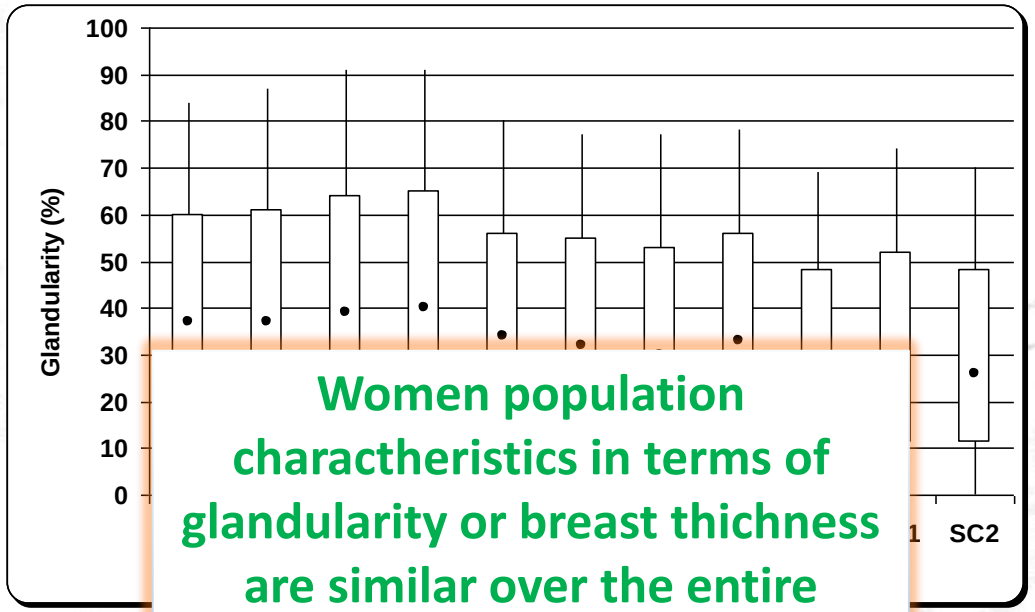
Physical charaterization of 11 mammo Units

Variation < 4 %

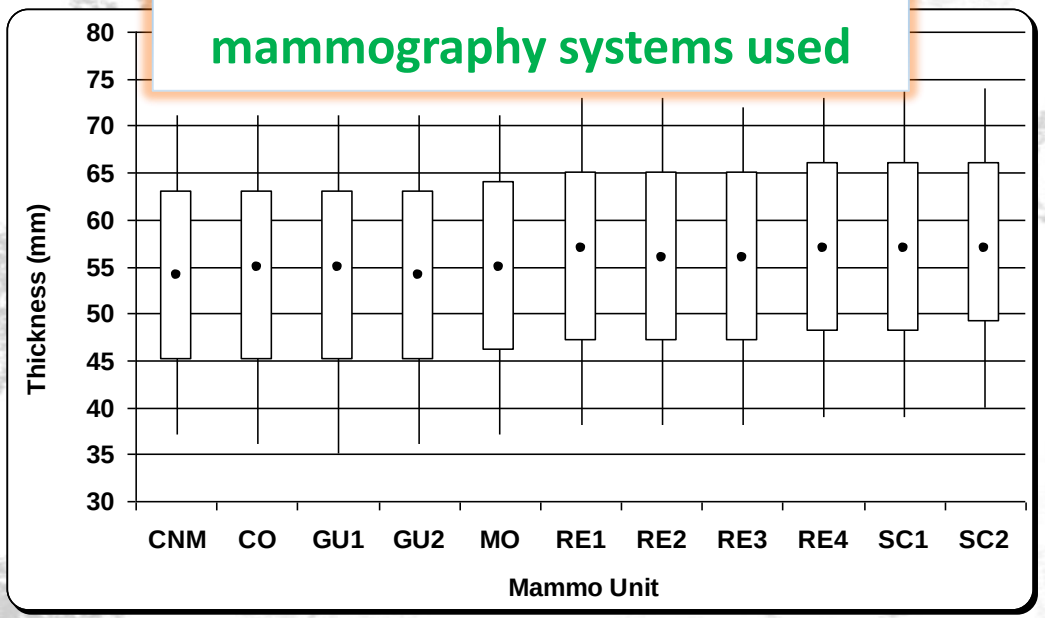
	Output µGy/mAs (1m)	HVL 28 kV Mo/Mo
CM	49,69	0,385
CO	49,37	0,384
GU1	51,22	0,381
GU2	51,01	0,381
MO	50,51	0,386
RE1	50,34	0,390
RE2	50,45	0,385
RE3	51,59	0,382
RE4	51,48	0,382
SC1	49,59	0,384
SC2	51,09	0,383

Variation < 2 %

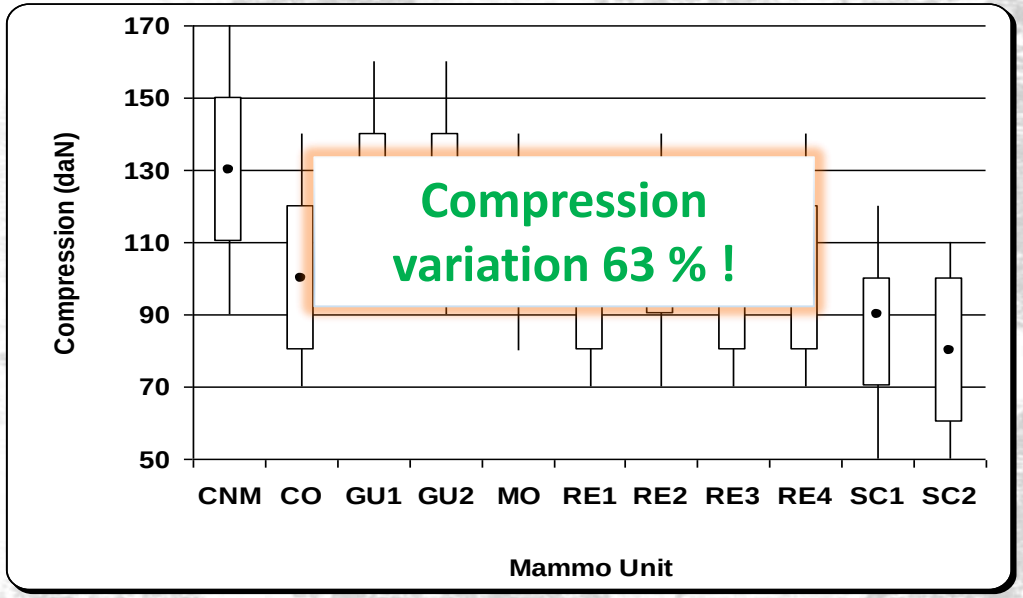
Glandularity



Women population charactheristics in terms of glandularity or breast thichness are similar over the entire Province and for all the mammography systems used



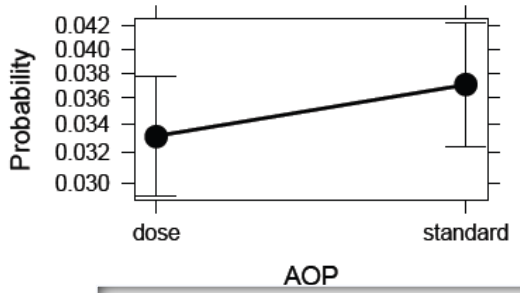
Compression force

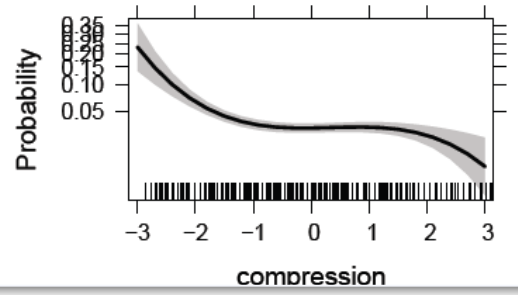


Compression variation 63 % !

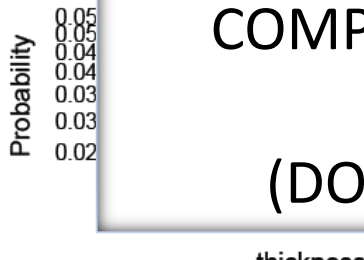
AOP	Negative	Recall	Recall Rate
Dose	11,947	447	3.61%
Standard	8,714	373	4.10%
Contrast	263	8	2.95%

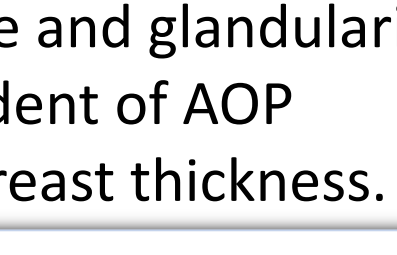
Recall probability linear mixed effects model analysis

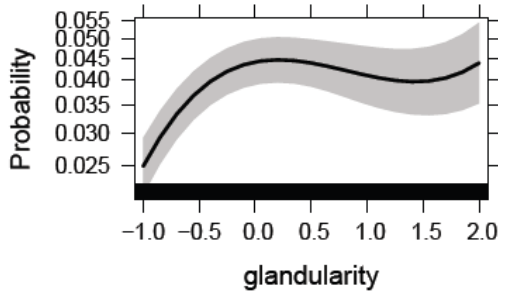




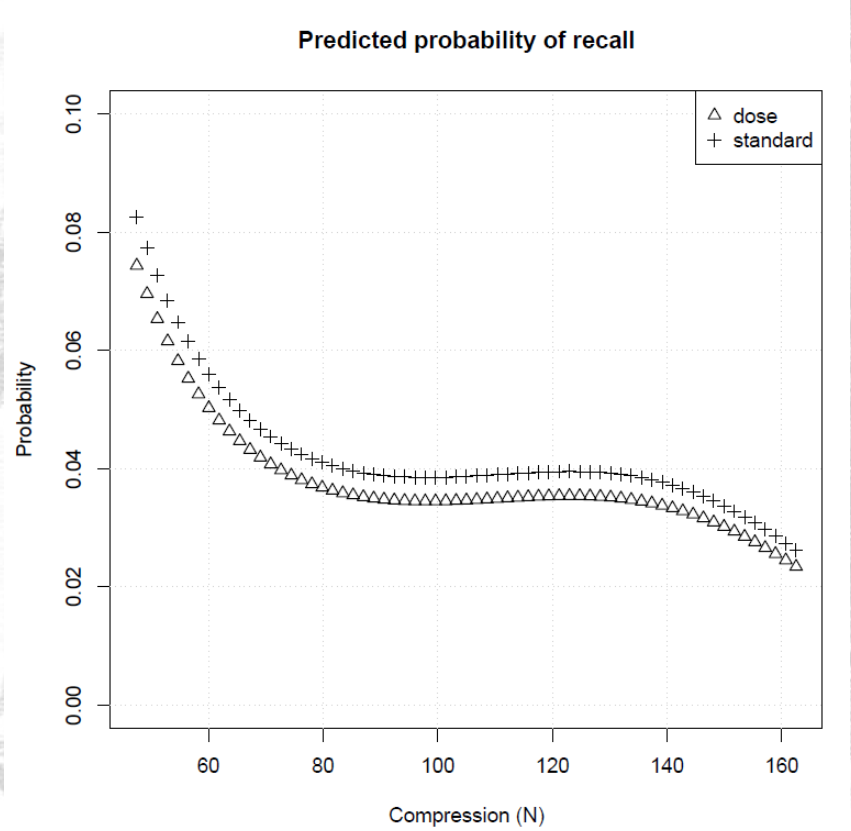
Recall probability depends on COMPRESSION, age and glandularity
It is independent of AOP
(DOSE !!!) and breast thickness.







	Chisq	Df	Pr(>Chisq)
AOP	2.13	1	0.144
poly(compression, 3)	55.32	3	<0.001
thickness	2.54	1	0.111
poly(age, 3)	20.73	3	<0.001
poly(glandularity, 3)	57.98	3	<0.001



Recall probability descrease in function of compression and became stable over 90/100 N

Q: Compression force… how much it's enough ?

In x-ray mammography, it is well known that the flattening of the breast improves image quality and reduces absorbed dose (citare Amended 2014 (Resolution 39)* ACR–AAPM–SIIM PRACTICE PARAMETER FOR DETERMINANTS OF IMAGE QUALITY IN DIGITAL MAMMOGRAPHY).

In the Euref protocol is stated: "***The compression of the breast tissue should be firm but tolerable. There is no optimal value known for the force, but attention should be given to the applied compression and the accuracy of the indication***."

→A: Since no optimal value is known our observation on recall rate dependence from compression force was used: the application of a compression force of at least 100N was suggested to the each radiographer.

Please adopt a standard !

→ AOP selection = DOSE

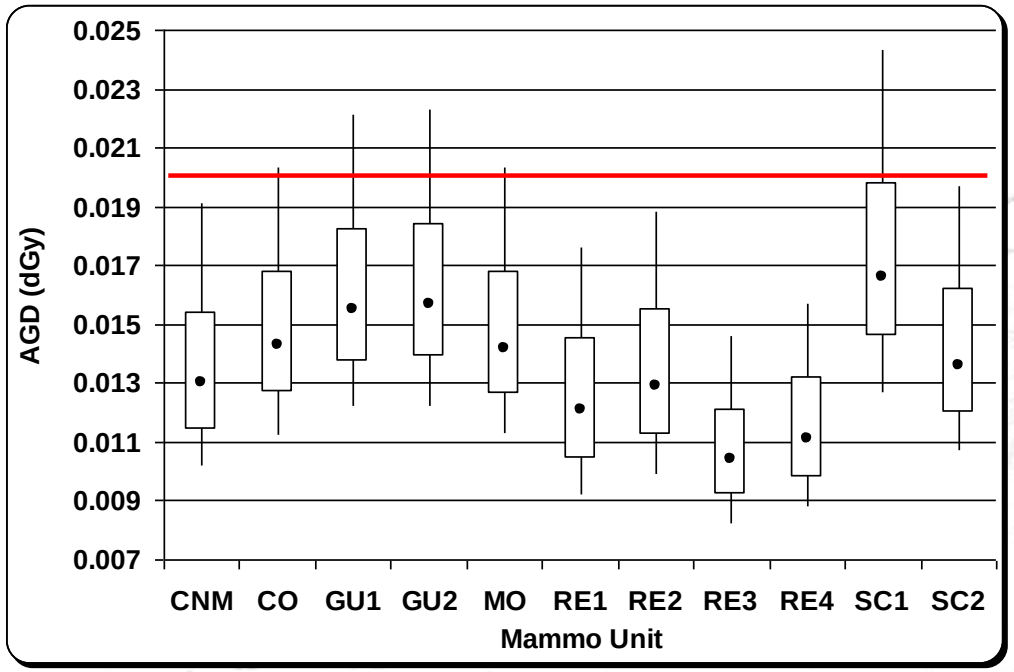
→ Compression Force ~ 100 N

Results compare periods before and after this standardization

(Jan-May Vs Jun-Dec 2014)

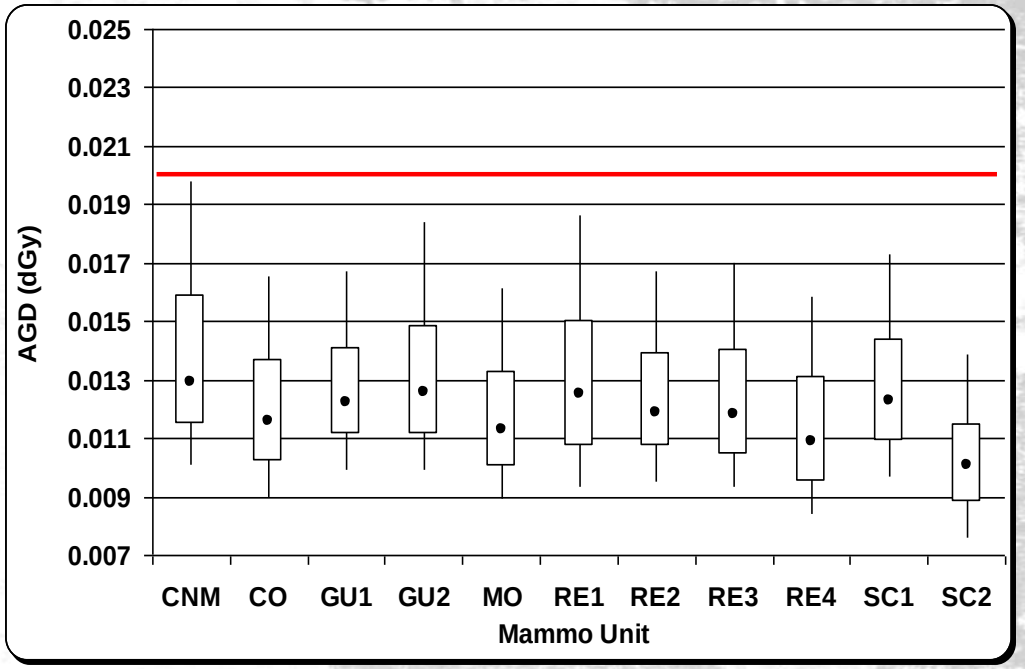
	Jan-May 2014	Jun-Dec 2014*
# Women	14,108	13,987

PRE-Standardization



Variation: 60%
Mean AGD: 1.4 mGy

POST-Standardization



- 14%

Variation: 28%
Mean AGD: 1.2 mGy

Standardization… It's not enough !!!

(Clinical) Image Quality Control is needed !

Standardization

compression force and AOP selection

→ lower dose and variability

+

Clinical control

Image quality… in a BSP ~

→ higher performance (cancer detection rate DR)

→ more stable performance (recall rate RR)

=

= 1° optimization step

Standardization + Clinical control = 1° optimization step

Standardization

		Jan-May 2014	Jun-Dec 2014
# women -->		14,108	13,987
	1st Qu.	1.13	1.07
AGD from 1.38 to 1.22 mGy			
	3rd Qu.	1.64	1.44
	1st Qu.	46.3	45.0
Thickness 1-2 mm lower			
	3rd Qu.	64.5	63.0
	1st Qu.	17.5	19.3
Glandularity ~ 2 % higher			
	3rd Qu.	59.3	62.3
	1st Qu.	90	103
Compression higher & more uniform			
	3rd Qu.	120	123

Clinical control

	Jan-May 2014	Jun-Dec 2014*
# Women	14,108	13,987
# Recalls	484	644
Detection rate increse of about 15 % !!!		
# True positive	63	71
Detection Rate DR ‰	4.47	5.08

* Preliminary result: recalls "on going": e.g. waiting for early recall (3-6-9-12 months) results

Linear mixed effects model analysis

Discrepancy between 1st - 2nd reader

	OR	2.5%	97.5%
2nd Period	1.094	0.965	1.242
AOP STD	0.834	0.678	1.025
AOP CNT	0.642	0.375	1.048
Thickness	0.988	0.976	1.001
Compression Force	0.999	0.999	1.000
AGD	**1.595**	1.127	2.226
Glandularity	1.020	1.012	1.029
I(Glandularity^2)	1.000	1.000	1.000
Age	0.757	0.684	0.839
I(age^2)	1.002	1.001	1.003

Fixed effects
- AOP dose
- first period

AGD seem to be significant …
further analysis demonstrate that, for both periods, the reader concordance were higher (3.14 % Vs 2.59 %) for lower dose level

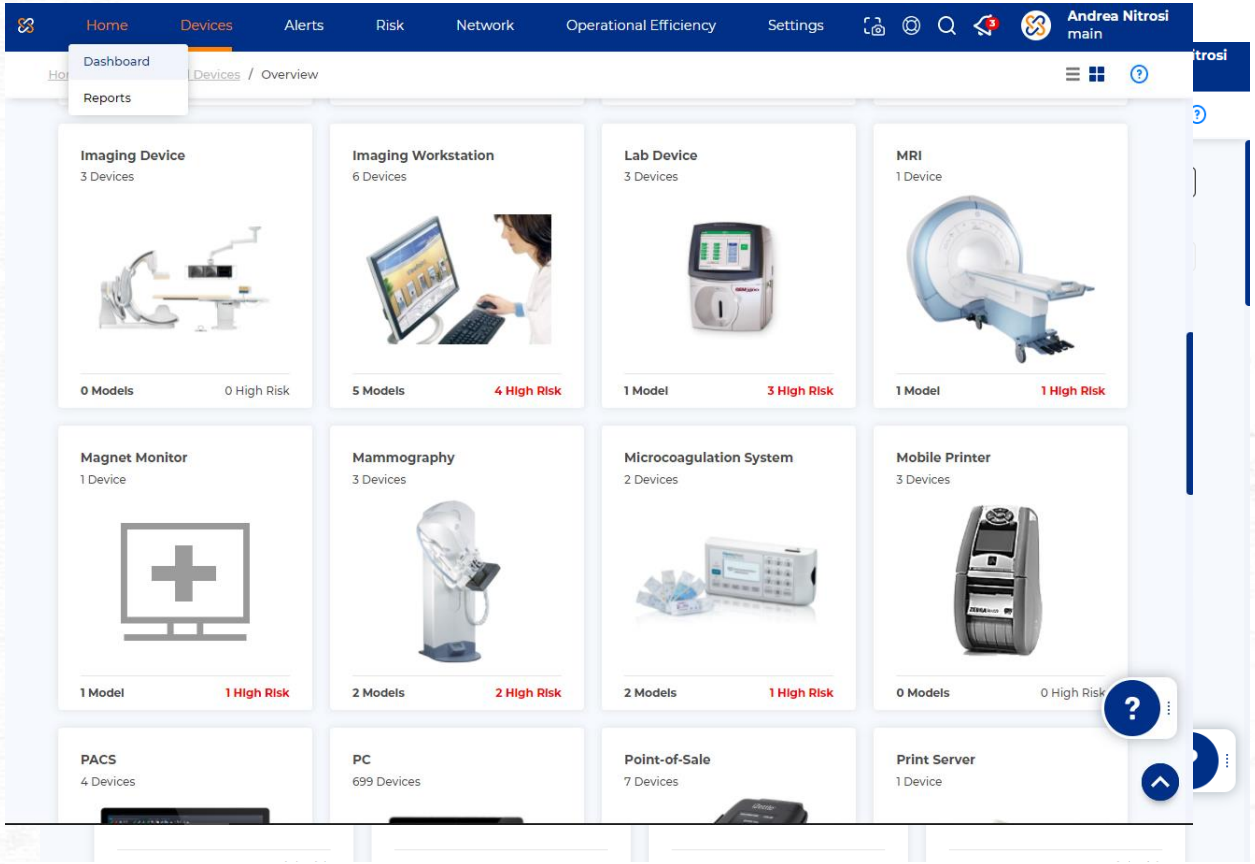
---

Recalls

	OR	2.5%	97.5%
2nd Period	**1.274**	1.118	1.454
AOP STD	0.822	0.693	0.972
AOP CNT	1.035	0.658	1.546
Thickness	0.978	0.960	0.997
I(Thickness^2)	1.000	1.000	1.000
Compression Force	0.999	0.999	1.000
Glandularity	1.027	1.019	1.036
I(Glandularity^2)	1.000	1.000	1.000
Age	0.733	0.660	0.814
I(age^2)	1.003	1.002	1.003

Fixed effects
- AOP dose
- first period

Only “Period” seem to be significant.

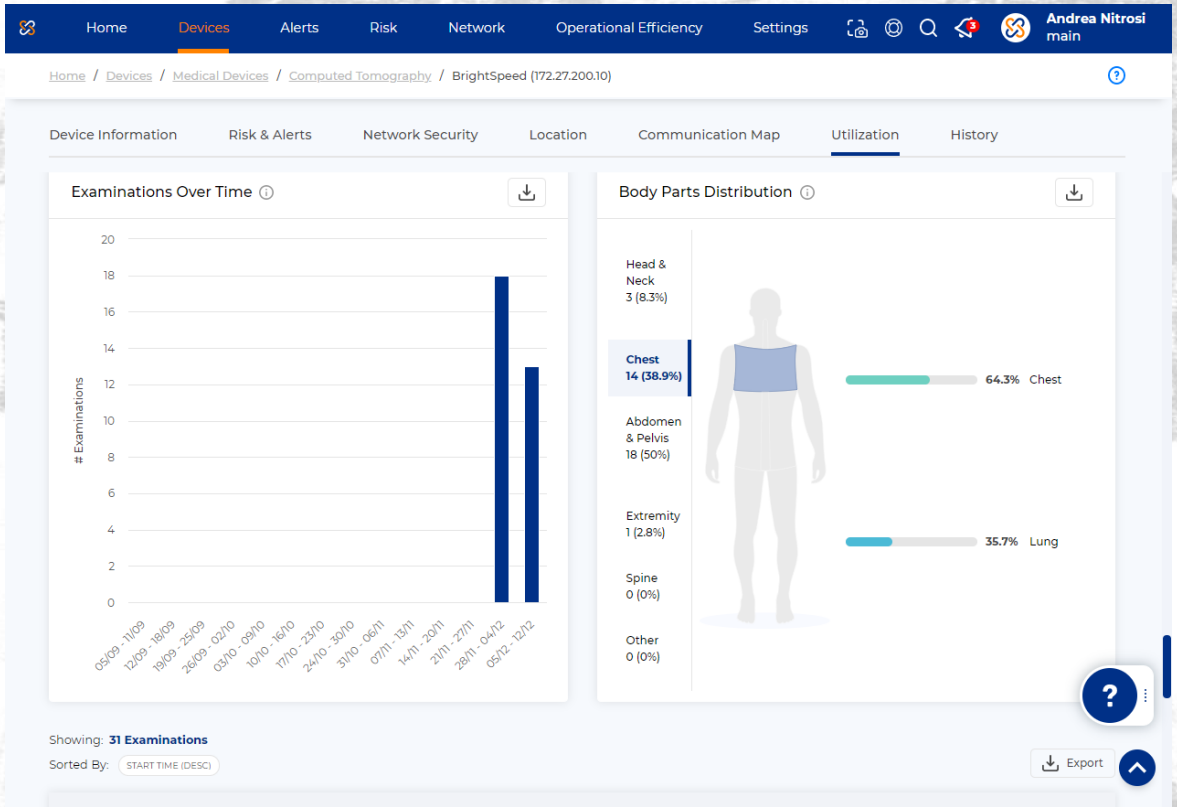


Is it necessary to have a dose monitoring system to do this type of analysis ?

Not anymore ... in principle it is NOT necessary to configure nodes and connections on modality / RIS / PACS / RDS but simply to **“listen”** the network !

Security Platform Agent can discovers and profiles every connected device, analyzes their risks, and automates responses to keep it safe and operating efficiently.

For some of that for medical device profiles, contextual anomaly detection (e.g. FDA warning), and risk identification with a unique approach are available, too !



Journal of Medical Radiation Sciences

Open Access

REVIEW ARTICLE

Mammographic compression practices of force- and pressure-standardisation protocol: A scoping review

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Keywords
breast, mammographer, mammography, review, screening

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Abstract

Introduction: As an efficient, effective and moderately inexpensive modality, mammography has been implemented as a cancer screening tool and in diagnostic management. However, appropriate breast compression is necessary for optimal outcomes. Current key measures of compression force are subjective and variable, giving rise to the concept of a 'personalised' pressure-standardisation protocol. **Methods:** A scoping review of the literature was performed using the Arksey and O'Malley framework to explore the existing force- and pressure-standardisation protocols in clinical application. A comprehensive search strategy and standardised study selection and evaluation were completed. This synthesis of existing knowledge can lead to the implementation of mechanically standardised mammographic compression pressure as a feasible tailored approach to clinical practice. Four databases (PubMed, MEDLINE, Embase and Scopus) were searched from the databases' inception to 13 December 2019 for relevant information, and eighteen articles were selected for analysis. **Results:** In addition to current protocol comparison, emerging key concepts include the reasoning behind standardisation, the benefits of improved diagnostic outcomes/decreased pain with negligible change in image quality and average glandular dose (AGD), and the recommendation of a 10kPa (approximate) pressure-standardisation protocol. Research to date is largely based abroad (Netherlands), with a strong focus on screening practices. Consequently, several gaps in the current literature were identified as potential directions for future investigation. **Conclusions:** As a suggested mammographic guideline, compression pressures of approximately 10kPa aid in image acquisition reproducibility both within and between women; pain levels decrease, with minimal variations to breast thickness, AGD and image quality.

Conclusions: As a suggested mammographic guideline, compression pressures of approximately 10kPa aid in image acquisition reproducibility both within and between women; pain levels decrease, with minimal variations to breast thickness, AGD and image quality.

Take it home:

Compression force → To be firm but tolerable
(~100 N for Reggio could be ok)

DOSE→ «ALARA»
(~AOP DOSE for Reggio could be ok)

Image quality in a BSP → recall rate RR ? detection rate DR ?

Dose monitoring systems (BUT NON ONLY) could allow
to standardize and optimize image acquisition setups

Optimization needs continuos monitoring of clinical results
over iterative application of standardization process → «**P**lan **D**o **C**heck **A**ct»

Thanks for your attention !

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