DRL's in Mammography: results from 3 dose audits

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Purpose: In this work we compare the results of 3 dose audits (2013, 2015 and 2018) for bilateral mammography screening exams performed in a full field digital mammography unit GE Senographe DS. The average entrance surface dose (ESD) was estimated for a sample of at least 30 standard breasts. The results are compared with the European DRL - ESD of the 3rd quartile of the dose survey. We also estimate the average absorbed dose to the glandular tissue within breast (AGD) for a wide range of breast thicknesses, and convert it into effective dose, E (mSv). Later, data was presented to the staff to induce a process of optimization as team effort.

Methods:

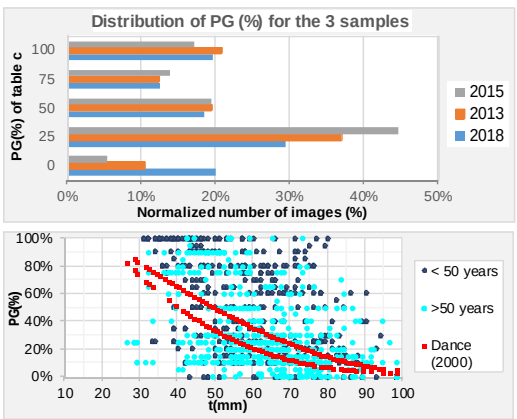
ESD was estimated from the incident air kerma and backscattering factors from (Jason 1994) for compressed breast thickness, t= 50 ± 10 mm. The percentage glandularity was determined using the qualitative method described by Byng (1994) and compared with Dance (2000) empirical formula. AGD was determined from measurements of the output and exposure data using appropriate conversion factors from IAEA (2007), Dance (2000), Dance (2009) for the t intervals: 34,5 ± 4,5 mm; 44,5 ± 4,5 mm; 54,5 ± 4,5 mm; 64,5 ± 4,5 mm; 74,5 ± 4,5 mm and 84,5 ± 4,5 mm. Effective doses were determined using ICRP 103 breast tissue weighting factor 0.12. Table 1 summarizes the sample characteristics used to estimate AGD and in brackets (*) numbers used to estimate ESD.

SAMPLE	2013	2015	2018
Total nr of patients (*)	88 (30)	180 (92)	275 (88)
Age of patient population (y)	58 ± 30 y	54 ± 22 y	55 ± 20 y
Number of images (*)	306 (118)	720 (367)	978 (350)
Number Proj CC/MLO (*)	153 (62/56)	360 (171/196)	489 (165/185)

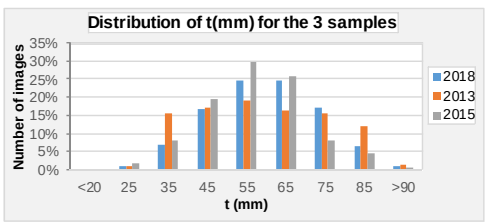
Results and Discussion:

The samples were homogeneous in terms of the breast percentage glandularity (PG) distribution. Differences occurred for glandularity intervals ≤10% and 11 to 25%.

Comparing Byng (1994) with Dance (2000), the Dance's empirical formula was not applied. The estimated uncertainty associated with our PG estimation methodology is <15% for all the dose audits

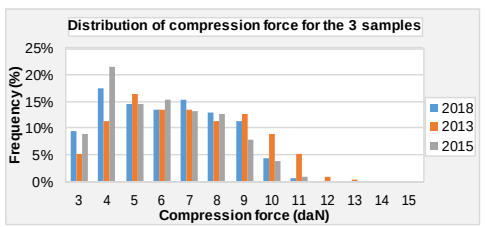


The samples were randomly collected - exams performed in 15 up to 30 consecutive days. Graph 2 shows the distribution in % of the compressed breast thicknesses, t (mm) of the 3 dose audit's. 2015 and 2018 samples behave Gaussian with median values for average breasts, 2018 (t = 61 mm) and 2015 (t = 58 mm).



In 2013 (t = 59 mm), because the sample was small, the images were not randomly collected.

An interesting change in the distribution of the compression force of the 3 samples can be observed in 2015 and 2018 where the use of very low compression force (3 and 4 daN) almost doubled, compromising the AEC mode functionality (≥3daN) of the mammography unit. The tendency of using <5 daN was recently corrected with a refreshment course for technicians on "applying the correct mammography technique".



This increase in the use of low daN related with the change in experience of the personnel responsible for performing the mammography exams.

PARAMETERS		2013	2015	2018
	kVp	29 ± 2 kVp (range from 26 to 31 kVp)		
	mAs	72 ± 30 mAs	85 ± 31 mAs	73 ± 29 mAs
A/F	RhRh	80%	88%	84%
A/F	MoRh	19%	12%	15%
A/F	MoMo	1%	< 1%	<1%
AOP	STD	100%	35%	94%
AOP	CNT	0%	64%	1%
AOP	DOSE	0%	0%	4%
AOP	MANUAL	0%	0%	1%

Table 2 (on the left) summarizes the acquisition parameters of the samples.

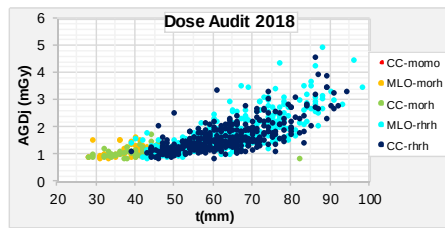
Table 3 (below) summarizes ESD results.

In 2015 there was a considerable increase in dose to the patient (30%) due to the use of Contrast Enhanced Automatic Optimization of Parameters (AOP CNT), mode. The results of 2013 and 2018 are below the European DRL's (10 mGy).

PROJ	ESD ± SD (mGy)			DRL
	2013	2015	2018	mGy
CC	7,0 ±1,3	9,6 ± 2,5	8,1 ± 2,0	10
MLO	7,5 ±1,6	10,1 ± 2,5	8,0 ± 1,9	10

Comparing with 2013, 2018 doses increased 6%, however 2013 sample was very small, so we established new Local DRLs based on the 3rd quartil of the distribution of 2018 Dose audit.

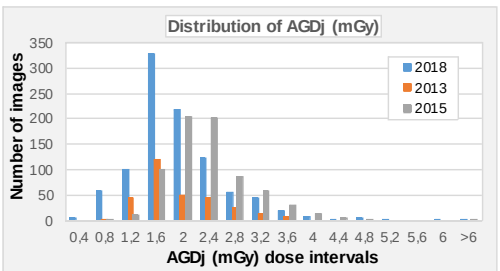
Graph 4 (on the right) shows the distribution of AGD versus t(mm) for the CC And MLO view and the different target filter combinations (2018).



t(mm)	2018 - AGD (mGy)			E
	CC	MLO	Total	(mSv)
30-39	1,2 ± 0,2	1,2 ± 0,2	2,4	0,29
40-49	1,4 ± 0,2	1,3 ± 0,2	2,7	0,32
50-59	1,6 ± 0,3	1,6 ± 0,3	3,1	0,38
60-69	1,8 ± 0,4	1,9 ± 0,4	3,7	0,44
70-79	2,1 ± 0,5	2,3 ± 0,5	4,3	0,52
80-89	2,5 ± 0,6	2,9 ± 0,6	5,3	0,64

Table 4 summarizes total average AGD (mGy) and E(mSv) for the complete examination according with different t(mm) intervals obtained in 2018 dose audit.

E ranged from: E = 0.29 mSv for small breasts (34.5±4.5mm) to E= 0.64 mSv for very large breasts (84.5±4.5mm) with larger compressed breast thickness associated with a higher AGD (E). Graph 5 (below) represents the **A**verage **G**landular **D**ose of each projection, AGDj (mGy), frequency in the sample per 0,4 mGy intervals. Doses distribution in 2018 reflect those from 2013 with a much larger sample. In 2015 there is a clear shift to higher AGDj (30%).



Whole Incertitude of the AGD determination method is < 21%.

Conclusion:

The results of 3 dose audits (2013, 2015, and 2018) performed at IPOCFG, EPE proved to be an important part of a quality assurance program. In 2015, dose audit analysis identified 30% increase in dose results exceeding European DRLs, due to an increased use of AOP CNT mode. Information given to the technicians was sufficient to alert them to the importance of the AOP modes on dose results. In 2018 a tendency to use very low compression forces was identified and induced the introduction of refreshment courses on "Applying correct mammography technique". These should be applied on an regular basis.