Latin American results in diagnostic mammography under IAEA Programme: Radiological Protection of Patients in Medical Exposures (TSA3)

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Abstract Latin American countries (Argentina, Brazil, Chile, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Paraguay, Uruguay and Venezuela) working under IAEA Technical Cooperation Programme *TSA3 Radiological Protection of Patients in Medical Exposures* have joined efforts in the optimization of radiation protection in mammography practice. Through surveys of image quality and patient doses, the region has a unique database of dose reference levels for analog and digital equipment that will direct future optimization activities, towards the early detection of breast cancer among asymptomatic women. During RLA9/057 (2007-2009) 24 institutions participated in a dose survey that included verification by the radiologist of European image quality criteria for each patient; in this phase only analog equipment was included. Regional training on methodology and measurement equipment was addressed in May 2007. Mean Glandular Dose (D_G) was estimated using the incident kerma in air and relevant conversion coefficients for both projections (CC and MLO). For phase two, RLA9/067 (2010-2011), it was decided to include also digital systems in order to see their impact in future dose optimization activities. Any new country that joined the project received training in the activities through IAEA expert missions. 29 new institutions participated (9 analog and 20 digital equipment). A total of 2600 patient doses were collected during this study. 87% fulfilled 80% of image quality criteria and from them D_G (mGy) for both projections were estimated for each institution and country. Regional results (75 percentile in mGy) show for CC and MLO respectively: RLA9/057 (analog) 2.63 and 3.17; RLA/067: 2.57 and 3.15 (analog) and 2.69 and 2.90 (digital). Regarding only digital equipment for CC and MLO respectively, CR systems showed 2.59 and 2.78 and DR systems 2.78 and 3.04. Evaluation of image criteria for digital systems showed a higher score on an overall basis.

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Based on the BSS reference dose (3mGy), it can be observed that there is enough room to start optimization processes in LA; several countries or even particular institutions have values much higher than the 3mGy. Main issues to address are: lack of well established QA programs for mammography, not enough medical physicists with training in mammography, an increase in patient doses with the introduction of digital equipment and to create awareness on radiation risk and optimization strategies.

Key words: mammography, quality control, mean glandular dose, Latin American, IAEA.

1. Introduction

Incidence and mortality of breast cancer among Latin American women present the same behavior as worldwide. Incidence has been increasing in the last 2 decades, placing it among the first or second cancer in women depending on the country. Mortality has also increased at a much lower rate. Age behavior is also similar with a marked increase among women aged 50 years and older [1].

Diagnostic mammography is carried out in all countries mainly because no formal mammography screening programs are established in the region. Common practice is the referral of a mammographic examination during a general / specialist practitioner consultation on a public or private health level. In this scheme, frequency of mammograms varies from 1 to 3 year intervals.

In order to improve the diagnostic quality of mammograms and patient radiation protection, Latin American countries have been working with the IAEA regional program TSA3 Radiological Protection of Patients in Medical Exposures. This project has 7 main areas that address patient radiation protection and optimization: adult and pediatric radiology, mammography, interventional radiology, computed radiology, nuclear medicine and radiotherapy. Previous work on mammography generated IAEA-TECDOC 1517: *Control de Calidad en Mamografía Diagnóstica* (QC in diagnostic mammography) [2].

Project TSA3 has had 2 phases from 2007-2009 and from 2010-2011. A software was designed to help implementation of publication TECDOC 1517 [3] and during this time 2 additional publications from the Agency became available (Human Health Series 2 and 17) [4,5].

The region lacks well established QA/QC culture, qualified personnel (medical physicist and radiographers) and strong regulations on mammography equipment. Due to the above reasons one of the project objectives was to establish base line information regarding patient radiation protection and optimization in diagnostic mammography via a dose survey. This paper will present only findings regarding mean glandular doses (D_G) as a way to direct future optimization activities.

2. Methods

During phase I (RLA/9/057: 2007-2009) a total of 24 institutions participated in the dose survey. Only analog equipment was included in this phase. The countries participating and the number of institutions from each is: Argentina (ARG) 1, Brazil (BRA) 10, Chile (CHI) 2, Costa Rica (COS) 4, Ecuador (ECU) 1, Nicaragua (NIC) 1, Paraguay (PAR) 1 and Uruguay (URU) 4.

In May 2007, a regional training course was held in Costa Rica for medical physicists responsible for data collection. Methodology to obtain D_G is the one described in IAEA TECDOC 1517 [2] and Dosimetry in Diagnostic Radiology: an International of Code of Practice [6] using the following equation:

$$D_G = c_{D_{G50},K_{i,PMMA}} \, s \, K_i \qquad (1)$$

where: K_i is the incident air kerma, s is the s factor which gives a correction that depends on the target filter combination and $c_{DG50,Ki,PMMA}$ is the conversion coefficient used to calculate the mean glandular dose to a 50 mm standard breast of 50% glandularity from the incident air kerma for a 45 mm PMMA phantom.

Hands on experience at a local hospital enabled the participants to review methodology, handle the equipment and the specially designed spread sheets. During this first year the IAEA bought each country the necessary equipment for the dose measurements (PTW Unidos electrometer with a mammographic ionization chamber, PTW Diavolt, aluminum sheets, photometer, ACR image quality phantom and other miscellaneous equipment).

During a first visit by the medical physicist basic QC test were performed on the machine to assure the accuracy of the parameters that will affect the dose estimation. Recollection of data consisted in measuring the output and HVL for all kVps used in the clinical practice. Radiographers collected for each patient view: kVp, breast thickness and mAs. Mean glandular doses were automatically estimated in the spread sheet and the complete results were sent to the regional coordinator for future analysis.

Sample size for each participating institution consisted of 25 patients for craniocaudal (CC) and mediolateral oblique (MLO) each. Thickness of the breast was restricted to 4-6 cm compressed breast with a glandularity of 50%/50% according to image evaluation by radiologist. Each view has also scored according to the European Quality Criteria [7] by the radiologist, only patients with a score of 80% or higher entered the study to assure that image quality was adequate.

During phase II (RLA/9/067: 2010-2011) the decision was taken to include digital mammography units in the study. Each country could decide if more institutions with analog equipment participated or only new with digital equipment. For this phase new countries entered the regional activities, and each received during 2010 expert missions to explain methodology and data collection. Participating institutions (analog/digital) for each country is as follows: ARG (2/2), BRA (1/10), CHI (1/0), COS (0/3), Cuba (CUB) (1/0), Guatemala (GUA) (2/1), Mexico (MEX) (0/1), NIC (1/0), PAR (0/1), EL Salvador (SAL) (1/0), Venezuela (VEN) (0/2), for a total of 9 new analog equipment and 20 digital equipment.

New data collection sheets were developed for the digital units. Mean glandular doses were also obtained by measurement of incident air kerma and patient parameters, following methodology of IAEA Human Health publication No.17 [5].

$$D_G = g_{53}\, c_{53}\, s\, K_i \qquad (2)$$

where: K_i is the incident air kerma, s is the s factor which give a correction that depends on the target filter combination and g_{53} is the factor that converts entrance air kerma o the mean glandular dose for the 53 mm thick standard breast and c_{53} is the conversion factor which allows for the glandularity of the 53 mm thick standard breast.

3. Results

Table 1 presents a summary of the number of participating institutions per country during each phase of the project. A total of 53 institutions participated, 33 with analog units and 20 with digital units; of the digital units 10 were CR units and 10 were DR units.

Table 1. Number of institutions with analog or digital equipment per country

Country	**RLA /9/057**	**RLA /9/067**		
	Analog	**Analog**	**Digital**	**Totals**
ARG	1	2	2	**5**
BRA	10	1	10	**21**
CHI	2	1	-	**3**
COS	4	-	3	**7**
CUB	-	1	-	**1**
ECU	1	-	-	**1**
GUA	-	2	1	**3**
MEX	-	-	1	**1**
NIC	1	1	-	**2**

PAR	1	-	1	**2**
SAL	-	1	-	**1**
URU	4	-	-	**4**
VEN	-	-	2	**2**
Total	**24**	**9**	**20**	**53**

Figures 1 and 2 show results for D_G (mGy) for each participating institution with analog equipment for CC and MLO views respectively.

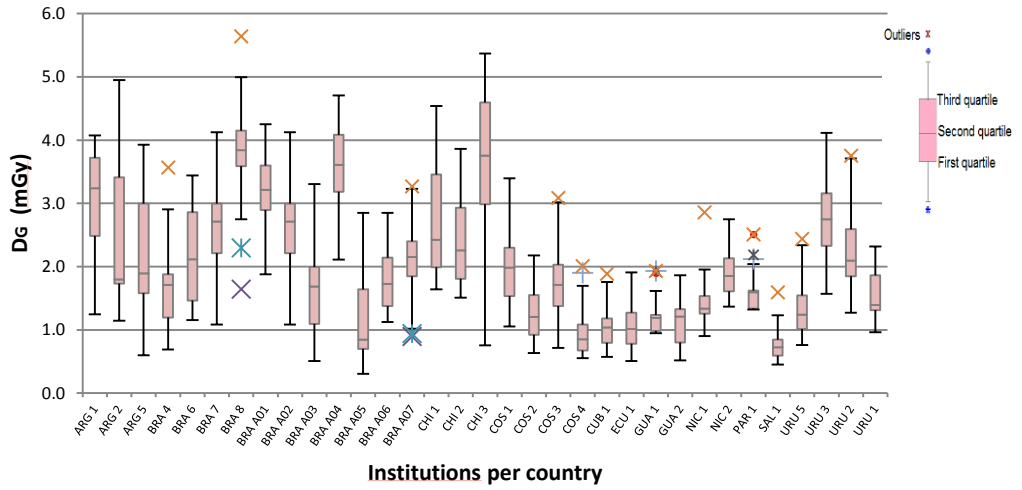

Figure 1. D_G (mGy) for each participating institution with analog equipment for CC

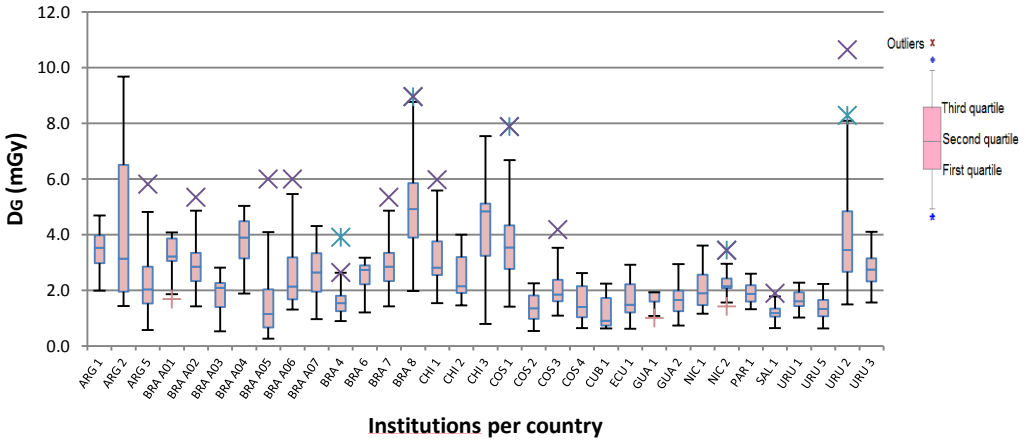

Fig 2. D_G (mGy) for each participating institution with analog equipment for MLO

Figures 3 and 4 show results for D_G (mGy) for each participating institution with digital equipment for CC and MLO views respectively.

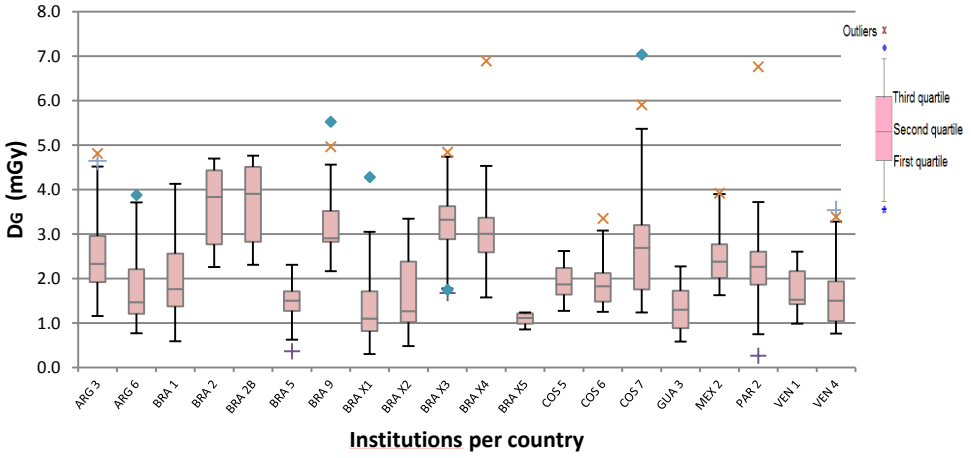

Fig 3. D_G (mGy) for each participating institution with digital equipment for CC

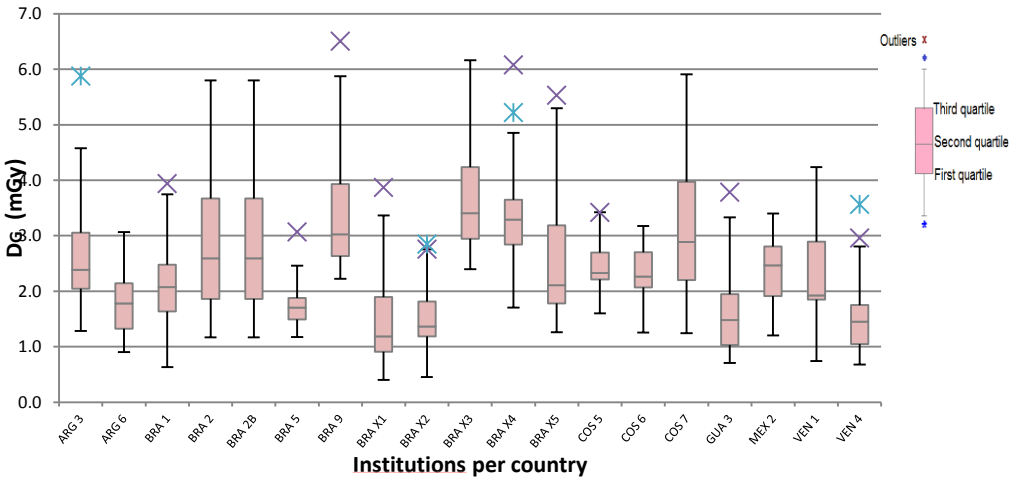

Fig 4. D_G (mGy) for each participating institution with digital equipment for MLO

Analysis of individual patients mean glandular doses produced Figure 5 (analog equipment for CC view). Similar figures were obtained for all combination of views (CC and MLO) and type of equipment (analog, digital CR and digital DR). Important results from this analysis are summarized in Table 2, where the percentage of patients above the 3 mGy recommended value is displayed.

Also for optimization purposes the percentage of patients above 2 mGy (current achievable level in many protocols) [4,5,8,9] is also presented.

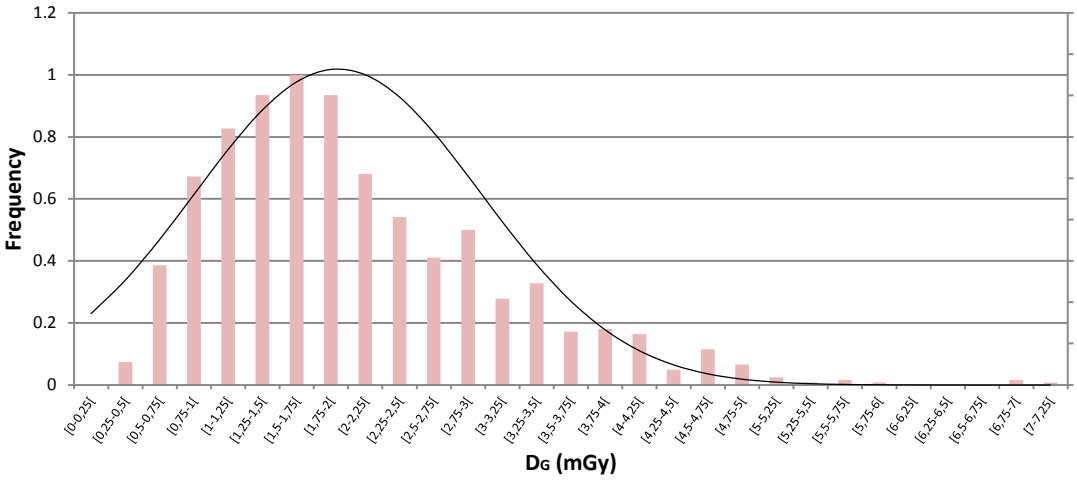

Figure 5. Frequency of D_G for analog equipment CC view

Table 2. Percentage of patient doses above 3 and 2 mGy.

Type of equipment	CC view		MLO view	
	3 mGy	2 mGy	3 mGy	2 mGy
Analog	17	42.5	26	57
Digital CR	15	44	23	52
Digital DR	19	52.5	26	66

Using the 75th percentile (or third quartile) one can obtain a good estimate of the diagnostic reference level (DRL) for a particular country or for the whole Latin American region. Table 3 shows the results for both views.

Table 3. DRLs for mammography for each country and for the region

Country	CC			MLO		
	Analog	CR	DR	Analog	CR	DR
ARG	3.37	2.21	2.96	4.14	2.15	3.06
BRA	2.97	2.80	3.31	3.44	3.03	3.46
CHI	3.89	-	-	4.30	-	-
COS	1.98	3.20	2.24	3.36	3.97	2.70
CUB	1.18	-	-	1.73	-	-
ECU	1.27	-	-	2.22	-	-
GUA	1.32	1.73	-	1.94	1.95	-
MEX	-	-	2.77	-	-	2.80

NIC	2.11	-	-	2.46	-	-
PAR	1.62	-	2.61	2.18	-	*
SAL	0.85	-	-	1.35	-	-
URU	2.62	-	-	3.06	-	-
VEN	-	2.17	1.94	-	2.89	1.75
REGIONAL	**2.63**	**2.59**	**2.93**	**3.17**	**2.78**	**3.04**

*Paraguay did not send data for digital MLO

4. Discussion and Conclusions

Good participation among Latin American countries resulted in 2600 patient doses collected from 53 institutions, 33 (62%) were analog equipment and 20 (28 %) were digital equipment (with 50 % CR and 50% DR). Figures 1 to 4 show: there is a wide spread in doses among all countries; even for an individual country behavior is not uniform among institutions. Many institutions have the 75th percentile above the recommended 3 mGy value (analog CC 33% institutions, analog MLO 46 % institutions, digital CC 30% institutions, and digital MLO 40 % institutions).

On individual patient doses the IAEA Safety Basic Standards publication 115 [10] has set a DRL of 3 mGy for CC and MLO projections, but recent protocols, such as the United Kingdom and European and even IAEA Human Health Series [4,5,8,9] have an acceptable value of $D_G \leq 2.5$ mGy and an achievable $D_G \leq 2$ mGy, so information from Table 2 shows that there is enough room for optimization actions in the region.

Regarding country's DRL for mammography, there is no significant decrease for digital equipment as should be expected. From Table 3, all regional DRL´s values are above the new 2.5 mGy acceptable level for D_G. DRL values for digital DR equipment are higher than for digital CR equipment.

Following this dose survey as part of the activities of project TSA3, specific actions to optimize diagnostic mammography practice have to be undertaken. Common problems in participating countries are lack of medical physicists trained in diagnostic radiology with emphasis in mammography. As in other countries in the world medical physicists are few and are mainly working in radiotherapy and nuclear medicine departments. Complete sets of equipment for QC tests are also rare. There is lack of regulations regarding mammography requirements in most of the countries. A mayor new problem is the introduction of digital equipment, the transition towards digital is not easy and usually optimization procedures have to be introduce in order to lower radiation doses but still maintaining image quality. Many digital equipment enter our countries with no software capability for QC test and service engineers are not fully trained in this new technology. Image quality on analog equipment was carried out using ACR phantom and results

demonstrated room for optimization [11]. In the new phase of project (2012-2013) image quality of digital mammography equipment will be carried out in order to correlate doses with image quality. Regional activities will be focused on increasing the number of trained medical physicist and radiographers, implementation of QC/QA programs, transition from analog to digital, reinforcement of regulations and general awareness on radiologist and staff administration on the importance of QC programs.

If national screening mammography programs are introduced all above actions are urgent since excellent image quality at acceptable dose levels are mandatory and all regional actions on the optimization of mammography practice need to be introduced without further delay.

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