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Typical value of the mean glandular dose in Full-field Digital mammography at the Public Hospital in Brazil

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Abstract: The mean glandular dose (MGD) provides dosimetric information about the quantity of radiation received by the mammary glands during mammographic exposures. There is, therefore, the need to analyse the radiation dose received by patients presenting for mammography examinations. This study presents the establishment of typical values for the mean glandular dose (MGD) in full-field digital mammography (FFDM) in a public hospital in Brasil. The research responds to the International Commission on Radiological Protection (ICRP) guidelines and aims to optimize radiation doses while ensuring the diagnostic quality of mammograms. By analyzing DICOM images obtained from patients, typical MGD values were calculated for different compressed breast thicknesses (CBT). The study involves a comprehensive review of exposure parameters and patient data, extracted via the Volpara Manager Dose software and DICOM Header. The results provide an essential reference for local Diagnostic Reference Levels (DRLs) in mammography, supporting ongoing efforts to enhance imaging safety and image quality. These findings also provide a framework for the future implementation of local DRLs across public hospitals, emphasizing the importance of consistent radiation dose management in mammography.

Keywords: mean glandular dose - MGD, typical value, Diagnostic Reference Levels – DRL, mammography.

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Valores típicos de dose glandular média em mamografia digital direta em um Hospital Público no Brasil

Resumo: A dose glandular média (DGM) fornece informações dosimétricas sobre a quantidade de radiação recebida pelas glândulas mamárias durante exposições mamográficas. Portanto, há a necessidade de analisar a dose de radiação recebida por pacientes que se submetem a exames de mamografia. Este estudo apresenta o estabelecimento de valores típicos para a dose glandular média (DGM) na mamografia digital direta (FFDM) em um hospital público. A pesquisa atende às diretrizes da Comissão Internacional de Proteção Radiológica (ICRP) e busca otimizar as doses de radiação, garantindo a qualidade diagnóstica das mamografias. Ao analisar imagens DICOM obtidas de pacientes de um hospital público no Brasil, foram calculados valores típicos de (DGM) para diferentes espessuras de mama comprimida (CBT). O estudo envolve uma revisão abrangente dos parâmetros de exposição extraídos do cabeçalho DICOM e comparado com os dados do software Volpara Manager Dose e o. Os resultados oferecem uma referência essencial para os Níveis de Referência Diagnóstica (NRDs) locais em mamografia, apoiando esforços contínuos para melhorar a segurança e a qualidade das imagens. Esses dados fornecem uma base para a futura implementação de (NRDs) locais em hospitais públicos, enfatizando a importância da gestão consistente da dose de radiação na mamografia.

Palavras-chave: dose glandular média, valores típicos, Níveis de referência local, mamografia.

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1. INTRODUCTION

Diagnostic Reference Levels (DRLs), introduced by the International Commission on Radiological Protection (ICRP) in the early 1990s, serve as a monitoring measure to minimize considerable variations in doses between different imaging centers [1]. The methodology for estimating radiation doses to the breast has varied, encompassing factors such as screening techniques, breast granularity patterns, thickness, tube voltage (kVp), and spectrum parameters (target-filter combination, average value layer). A systematic review in 2014 highlighted the different types of protocol for establishing (DRLs) in Full Field Digital Mammography (FFDM), leading to significant variations in methods and challenges in comparing studies. Responding to these challenges, the ICRP published further guidelines in 2017 to standardize the protocols for (DRL) establishment.

Mean glandular dose (MGD) represents the effective absorbed dose to the glandular tissue of the breast, typically estimated using a phantom [2]. Globally, many countries have implemented (DRLs) for mammography screening to optimize radiation doses based on different detector technologies [3]. DRLs define an optimal dose range that maintains the diagnostic integrity of mammograms while ensuring patient safety.

As part of establishing local and national (DRLs), we contribute typical mean glandular dose values for each service. A typical value represents the median of a data distribution for a Diagnostic Reference Level (DRL) quantity associated with a clinical imaging procedure [4]. This distribution is typically derived from data collected within a single healthcare facility that may have multiple x-ray rooms, or from a small cluster of healthcare facilities. The data for these typical values are gathered through either a local survey or a comprehensive review of existing local data.

Typical values serve as a parameter within the facility, promoting ongoing optimization of imaging practices. They act as a local comparator, akin to local (DRLs), aiding in the continuous enhancement of imaging quality and safety. These values are particularly useful in settings where the number of x-ray rooms or healthcare facilities is too limited to establish a robust local (DRL).

In cases where new technologies or techniques are introduced, typical values may be established for an individual facility. This helps in assessing the effectiveness and safety of the new approach by providing a direct, relevant comparator. By setting these parameters, facilities can ensure they maintain consistent and safe radiation levels, while also striving for technological and procedural improvements. Reports from various countries indicate ongoing monitoring and reporting of radiation doses in breast cancer screening programs [5].

This retrospective study aims to report on hospital a typical value of verage glandular dose (MGD) adjusted for each equivalent compressed breast thickness (CBT), along with the mean glandular dose from the DICOM header and Volpara Software. [6].

2. MATERIALS AND METHODS

To implement typical value of the mean glandular dose (MGD), a retrospective cross-section design, between the period of August 2022 to December 2022, was carried out on the data of 270 participants and 1400 exposures/Incidences with randomly selected patients to obtain DICOM images from (FFDM). In this department, providing the images is a public reference hospital equipped with a Shimadzu Full-field Digital mammography (FFDM) unit. The acquired images were obtained using Automatic Exposure Control (AEC) and will be analyzed using Volpara Manager Dose software to compare with the Header DICOM. The

mammography unit works five times a week, with an average of 18 cases each day. Only data of patients who had both breasts exposed were included in the study. Images selected and saved in Raw data format for this work that failed to be read by the Volpara software were disregarded.

2.1. Selection of Establishments

To determine the typical value of the mean glandular dose (MGD), images obtained from public hospital with cooperation agreements for research with CDTN/LARAM (Laboratório de Radioproteção Aplicada à Mamografia) were used, in accordance with the approval of the ethics committee of each institution - CAAE 25993919.5.0000.9507. The public hospital has just one room for Mammography Equipment.

2.2. Sample Election Criteria

The studies were conducted without distinction between asymptomatic and symptomatic women or any other classification, who attended the service for mammography exams. For the study, we used right and left Craniocaudal (CC) and Mediolateral oblique (MLO) incidences. Complementary images such as breast implants, mastectomy, repeat exams, magnification incidence, and images with incomplete data were discarded for preliminary analysis.

2.3. Data Extraction for Typical Value Establishment

Data was collected manually from the mammography system´s computer by recording at the hard drive. Following dat collection, the data were entered into Volpara Software for analysis. The tables compare the mean glandular dose (MGD) and breast thickness as measured by two different methods: DICOM header data and Volpara software.

Information pertaining to exposure factors, patient details and radiation dose was retrieved from the DICOM header. This data was then automatically exported to a software Volpara Data Manager: Version 1.1 For (MGD) analysis (Algorithm Volpara).

2.4. Analysis and Data Extraction

In this step, data extraction is performed to analyze the data individually or collectively, to present trends and evaluate values, as well as compare them with other standards. The analysis of this work is related to the establishment typical value of the (MGD), associated with different thicknesses and 75th and values for the median. The data obtained from the group of unprocessed mammography (Raw data) were extracted from the DICOM tags of the respective images. Information regarding the medical modality (mammography) included (MGD), compressed breast thickness (CBT), patient age, entrance surface dose, voltage value (kVp), and the product of electric current time - charge (mAs). All acquired images were with Automatic Exposure Control (AEC), which was used to select kVp and mAs. [6] The projections considered in the study were left craniocaudal (LCC), right craniocaudal (RCC), left mediolateral oblique (LMLO), and right mediolateral oblique (RMLO). Data extraction was performed by the author using anonymization methods, for a spreadsheet without any content alteration, complying with data protection laws.

3. RESULTS AND DISCUSSIONS

Among the 270 patients, ages ranged from 32 to 89 years, with a mean ± standard deviation of 57.95 ± 11.16 years. The mean compression force for the (CC) and (MLO) projections were 129.42 ± 34.01N, and the mean (CBTs) were 54.24 ± 13.12 mm for (CC) and (MLO) projections. Table 1 presents a summary of data obtained from 1,400 mammographic incidents. A total of 730 exposures were recorded in the (CC) projections and 670 in the (MLO) projections. The (MGD) was

2.23 ± 0.76 mGy for CC and 2.70 ± 0.99 mGy for (MLO). Additionally, the typical (MGD) value, represented by the median, was 2.2 mGy for (CC) and 2.55 mGy for (MLO). These values are consistent with international reference levels for digital mammography and reflect the expected dose variations between (CC) and (MLO) views due to breast compression differences and tissue composition.

Table 1: Summary of data from Hospital total of 1400 incidences.

Parameters	CC	MLO
Number of total exposures/Incidences (FFDM)	730	670
Average patient age (DICOM header)	57.95	57.95
(Min-Max)	(32-89)	(32-89)
Mean Mean glandular dose (DICOM header)	2.23 ± 0.76 mGy	2.70 ± 0.99 mGy
Typical Value MGD (median)	2.2 mGy	2.55 mGy

The digital mammography system (FFDM) can display the values of (MGD) from the DICOM header and calculated by (Algorithm Volpara). See table 2, we have a reference adapted from the Brazilian standard IN92 [6]. The table includes comparisons between the reference and tolerance (MGD) levels for equivalent polymethylmethacrylate (PMMA) thicknesses and the actual (MGD) values measured from the DICOM headers and Volpara software, for both craniocaudal (CC) and mediolateral oblique (MLO) views. See at table 2, different values from the DICOM header with the values calculated by the VOLPARA algorithm. The p-values for the paired t-tests comparing the DICOM header values with the Volpara values are as follows: (CC – MGD) (mGy): p-value = 0.766, (MLO – MGD) (mGy): p-value = 0.771. These p-values indicate that there is no statistically significant difference between the DICOM header and Volpara values for both the (CC) and (MLO) (MGD) measurements.

Table 2: Mean glandular dose per thickness compared to IN92

Adapted IN92 (Anvisa)				Public Hospital			
Thickness (cm)		MGD (mGy)		CC - MGD (mGy)		MLO - MGD (mGy)	
PMMA	Mama equivalent	Reference	Tolerance	DICOM header	Volpara	DICOM header	Volpara
2	2.1	0.6	< 1	1.03 (1)	1.05 (1)	0.85 (1)	0.88 (1)
3	3.2	1	< 1.5	1.50 (5)	1.58 (4)	1.14 (5)	1.20 (5)
4	4.5	1.6	< 2	1.85 (23)	1.93 (22)	1.71 (13)	1.90 (10)
4.5	5.3	2	< 2.5	2.28 (29)	2.31 (25)	2.5 (14)	2.40 (13)
5	6	2.4	< 3	2.47 (19)	2.45 (18)	2.6 (22)	2.58 (20)
6	7.5	3.6	< 4.5	3.87 (5)	3.57 (5)	3.87 (11)	3.59 (11)

The values in parentheses refer to the analysis of incidences performed in the public hospital only with the thickness value informed by the DICOM header for 2.1; 3.2; 4.5; 5.3; 6; 7.5 cm, for comparison purposes with the normative instruction IN92 (Anvisa) of Brazil [6]. The data demonstrates that, across the range of compressed breast thicknesses (2 to 6 cm), the measured (MGD) values remain within the tolerance limits specified by IN92. Slight variations are observed between the (MGD) values derived from DICOM headers and Volpara, but these remain clinically acceptable. Slightly elevated (MGD) values exceeding the tolerance limits defined by IN 92 were observed only in the (CC) projection, as calculated by Volpara, for breast thicknesses of 2 cm and 3 cm.

See Table 3 the mean glandular dose (MGD) measured across 1400 incidences of breast imaging. The median of the mean glandular dose (MGD) in milligrays (mGy) extracted from the DICOM header is 2.34 mGy. The minimum and maximum (min-Max) range of observed doses, which vary from 0.83 mGy to 6.01 mGy. The average breast thickness in millimeters (mm) measured, with an average value of 54.24 mm ± 13.12 mm (this means the average thickness is 54.24 mm, with a standard deviation of 13.12 mm). The median of the mean glandular dose (MGD) at the 75th percentile of the DICOM data, which is 2.96 mGy.

The median of the mean glandular dose (MGD) in milligrays (mGy) calculated at Volpara Software is 2.32 mGy, the minimum and maximum (min-Max) range of observed doses, which vary from 0.86 mGy to 5.71 mGy. The average breast thickness in millimeters measured by Volpara, with an average value of 65.27 mm ± 32.69 mm.

Table 3: Total mean glandular dose (MGD) compared to DICOM and Volpara

All Projections	**MGD DICOM**	**MGD DICOM 75th**	**MGD (Volpara)**	**MGD (Volpara) 75th**
Median (mGy)	2.34	2.96	2.32	2.90
(Min-Max)	(0.83-6.01)		(0.86-5.71)	
Thickness (mm)	54.24±13.12		65.27±32.69	

The median (MGD) values are similar between the two methods, although Volpara reports a higher average breast thickness compared to the DICOM data.

4. CONCLUSIONS

The mean glandular dose (MGD) per exposure for (CC) 2.23 mGy and a standard deviation of 0.76 mGy, and (MLO) were 2.70 mGy with a standard deviation of 0.99 mGy. Therefore, this work aims to contribute to a typical value of the mean glandular dose (MGD) for a better understanding of the risks associated with conducting exams, as well as concerns about clinical image quality.

The present study established the first typical value of the mean glandular dose (MGD) for mammography examinations in the Hospital. The typical value of the mean glandular dose (MGD) for 2.1; 3.2; 4.5; 5.3; 6; 7.5 cm compressed thickness (Equivalent) for (CC) and (MLO) projections at the median established.

For all incidences analyzed, the value of the mean glandular dose (MGD) by thickness value reported by the dicom header was not significant from the value calculated by the volpara software.

The results from this study produce available tools of dose investigation in (FFDM). This tool should be used in the future to establish local (DRLs) for the publics Hospital of the group, because the quality control program must review all procedures to improve and reduce the doses currently used in digital mammography (FFDM) procedures.

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CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

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