Dosimetric evaluation of 2D mammography and tomosynthesis with synthesized images at the Fundación CTIC

Evaluación dosimétrica de mamografías 2D y tomosíntesis con imágenes sintetizadas en la Fundación CTIC

Nathaly Barbosa[1]
Aura María Pareja[2]
Karen Villamil[3]
https://doi.org/10.53903/01212095.301

Key words (MeSH)
Radiation dose
Mammography
Package inserts for the patient

Palabras clave (DeCS)
Dosis de radiación
Mamografía
Prospectos para el paciente

Summary

Objective: Given the concern about a higher dose when performing mammography with tomosynthesis and the few publications on comparative radiation doses between 2D mammography and tomosynthesis, we sought to demonstrate that mammography with tomosynthesis and synthesized images does not increase the dose compared to standard 2D digital mammography. ***Materials and Methods:*** Retrospective cross-sectional study. Data included patient information, acquisition parameters, entrance dose, and mean glandular dose per projection, differentiating between 2D acquisition and tomosynthesis. ***Results:*** A total of 689 mammographic projections were documented, of which 367 were tomosynthesis projections. The doses showed notable similarities between 2D mammography and tomosynthesis techniques. For CC projection, the average dose was 1.48 mGy in 2D acquisition and 1.45 in tomosynthesis (p=0.6) and in MOL, 1.63 mGy and 1.58 mGy respectively (p=0.09). ***Conclusions:*** Dosimetric values in tomosynthesis mammography were slightly lower than those in conventional mammography, highlighting the capacity to synthesize 2D images. The implementation of synthesized images is proposed as a strategy to optimize the radiation dose in mammographic studies, improving safety and efficiency in clinical practice.

Resumen

Propósito u objetivos: Debido a la preocupación por la aplicación de una dosis de radiación mayor en la mamografía con tomosíntesis y las pocas publicaciones sobre las dosis de radiación comparativas entre mamografía 2D y tomosíntesis, se busca demostrar que la mamografía con tomosíntesis e imagen sintetizada no incrementa la dosis frente a una mamografía digital 2D estándar. ***Material y métodos:*** Estudio retrospectivo de corte transversal. Los datos incluyen información del paciente, parámetros de adquisición, dosis de entrada y dosis glandular media por proyección, diferenciando entre adquisiciones 2D y tomosíntesis. ***Resultados:*** Se documentaron 689 proyecciones mamográficas, de las cuales 367 son de tomosíntesis. Las dosis mostraron similitudes notables entre las técnicas de mamografía 2D y tomosíntesis. Para la proyección CC la dosis promedio fue de 1,48 mGy en adquisición 2D y de 1,45 en tomosíntesis ($p = 0,6$) y en MLO de 1,63 mGy y 1,58 mGy respectivamente ($p = 0,09$). ***Conclusiones:*** Los valores dosimétricos en la mamografía por tomosíntesis resultaron ligeramente inferiores a los de la mamografía convencional, destacando además la capacidad de sintetizar imágenes 2D. Se propone la implementación de imágenes sintetizadas como estrategia para optimizar la dosis de radiación en los estudios mamográficos, con la consiguiente mejora en la seguridad y eficiencia de la práctica clínica.

[1]MSc in Physics, medical physics. Cancer Treatment and Research Center

[2]Luis Carlos Sarmiento Angulo (CTIC Foundation). Bogotá, Colombia.

[3]Radiologist, CTIC Foundation. Bogotá, Colombia. Diagnostic Imaging Technologist, CTIC Foundation. Bogotá, Colombia.

Functional Assistance Unit Diagnostic Imaging and Nuclear Medicine, CTIC Foundation. Bogotá, Colombia.

Introduction and theoretical framework

Digital breast tomosynthesis (DBT) has shown a higher rate of breast cancer detection in screening studies, with a decrease in the recall rate in patients who would require complementary studies, due to a better characterization of asymmetries, masses and areas of distortion, which increases the sensitivity and specificity in the detection of invasive cancer (1, 2).

When the technique was incorporated for screening and diagnosis, it was necessary to acquire traditional 2D projections in addition to the DBT study to increase the sensitivity and specificity of lesion detection, which implied a double exposure of the breasts, limiting the use of DBT on a regular basis (3).

The general concern about a possible indiscriminate increase in population radiation dose caused by DBT has recently been partially attenuated by the introduction of synthesized images obtained from tomosynthesis data (2DS); this allows acquisition of only the DBT scan and derivation of 2D images very close to standard mammograms without increasing radiation dose.

To date, few results have been published on radiation doses for DBT and particularly in Colombia there are no reference levels for 2D mammography or DBT. For this reason, the purpose of this study is to evaluate the radiation doses obtained in 2D digital mammography and breast tomosynthesis.

Methods

A retrospective cross-sectional study was performed, which included all patients undergoing 2D digital mammography and tomosynthesis mammography studies performed at the CTIC Foundation between July and October 2023. Patients with breast prostheses were excluded from the study, since the presence of prostheses could alter acquisition parameters and dosimetric results. Screening studies were excluded.

Procurement procedure

All images were acquired using a GE Senographe Pristina mammograph, with the automatic exposure control (AEC) system to optimize exposure parameters. Tomosynthesis images were acquired in step & shoot mode, with a 25° sweep and nine evenly distributed projections, using a combination of anode and Molybdenum/Molybdenum or Rhodium/Silver filter depending on breast thickness.

Information

The following information was recorded for each patient: age; breast thickness in craniocaudal (CC) and medial oblique-lateral (MOL) projections; acquisition parameters (mAs and kV); input dose (in mGy) per projection, mean glandular dose (MGD) per projection, differentiating between 2D mammography and tomosynthesis. Typical values were determined for average breast thicknesses following the methodology of the International Commission on Radiological Protection (ICRP) Publication 135 (4).

Statistical analysis

In the univariate analysis, for quantitative variables, median (as measures of central tendency) and interquartile ranges (as a measure of dispersion) were estimated for breast thickness, input dose and MGD for 2D and tomosynthesis acquisitions. Bivariate analysis was performed in relation to different breast thicknesses, in 10-millimeter ranges (< 30 mm; 30 mm-40 mm; 40 mm-50 mm; 50 mm-60 mm; 60 mm-70 mm; 70 mm-80 mm; > 80 mm).

To evaluate differences in relative radiation dose exposure between 2D procedures and DBT, after performing the normality test using the Shapiro-Wilk test, the independent samples t-test was used with a significance level of $p \leq 0.05$, analyzed in SPSS version 26 statistical software.

Results

There were 689 projections performed between July and October 2023, of which 367 were tomosynthesis images. In the patients evaluated with mean age of 55 ± 12 years (range: 29-89), the mean breast thickness in CC projection was 5.5 ± 1.3 cm and in MOL projection was 6.1 ± 1.4 cm. Following the methodology of typical ICRP values and given the most frequent breast thicknesses, representative doses were calculated as those for breast thicknesses of 5.5 ± 0.5 cm in CC and 6.0 ± 0.5 cm in MOL.

For the doses obtained in DBT, the mean glandular dose behavior was evaluated for specific breast ranges (< 30 mm; 30 mm-40 mm; 40 mm-50 mm; 50 mm-60 mm; 60 mm-70 mm; 70 mm-80 mm; > 80 mm). Table 1 also shows the distribution of image acquisition parameters (mAs, kV).

Table 1. Statistical distribution of acquisition parameters and mean glandular dose (MGD) for DBT acquisitions

Breast thickness (x)	*n*	Average mAs	Average kV	MGDmin	MGD25 %	MGD50 %	MGD75 %	MGDmax
< 30 mm	4	3.5	32.0	0.8	0.9	1.0	1.1	1.2
30 mm < x ≤ 40 mm	30	4.6	31.3	0.4	0.9	1.1	1.1	1.3
40 mm < x ≤ 50 mm	68	3.3	33.3	0.4	1.2	1.3	1.3	1.7
50 mm < x ≤ 60 mm	114	8.8	34.0	0.6	1.4	1.4	1.4	2.4
60 mm < x ≤ 70 mm	77	6.6	34.0	1.1	1.5	1.7	1.7	2.8
70 mm < x ≤ 80 mm	33	9.8	33.8	0.5	1.8	2.0	2.0	2.7
> 80 mm	22	12.6	32.8	0.5	1.3	2.5	2.5	2.9

Note: minimum values, 25th, 50th, 75th percentiles and maximum values for each breast thickness. *n* = number of studies

Dose characteristic values showed remarkable similarities between 2D and DBT mammography techniques (Figure 1). For CC projection the average dose was 1.48 mGy in 2D acquisition and 1.45 in tomosynthesis (p = 0.6) and in MOL 1.63 mGy and 1.58 mGy, respectively (p = 0.09).

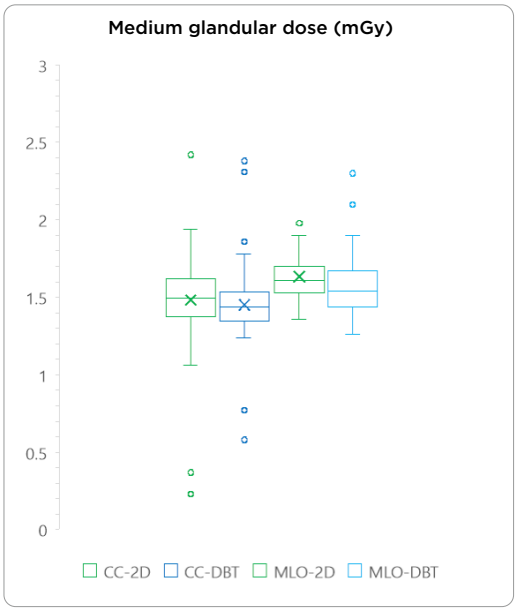


Figure 1. Typical values obtained by CC and MOL projection and by technique, 2D and DBT.

Discussion and conclusions

DBT has been implemented as a superior mammographic diagnostic technique to conventional 2D mammography due to its ability to improve lesion detection. There are multiple comparisons between these two techniques, both in studies with mannequins and in patients, mainly analyzing MGD. The literature reports that in dummies with a thickness of 60 mm and a glandular fraction of 14.3%, the average dose in DBT can be up to 83% higher compared to 2D digital mammography (5). In screening and diagnostic studies the values are lower, but a higher dose is consistently observed in DBT compared to 2D, with documented increases of between 20% and 38% (6-8). In the results of the work described here, no significant differences were found between conventional mammography and DBT.

Regarding breast thickness, it is important to take into account population variations. The average values of breast thickness found were 55 ± 13 mm for the CC projection and 61 ± 14 mm for the MOL, consistent with data reported in Colombia (CC: 48.25 ± 7.73 mm; MOL: 60.91 ± 11.25 mm) (9); although they are different from international studies (CC: 52.7 ± 12.0 mm; MOL: 56.0 ± 13.2 mm) (11).

In the present study, the MGD values obtained were lower than those described in a similar study carried out in Colombia, in which doses of 1.54 mGy in CC and 2.23 mGy in MOL were recorded for DBT (9). These differences could be explained when considering the calculation models, specifically in that of breast glandularity between the different commercial brands (6). Furthermore, the MGD values recorded in this study are within the range of 1.11 to 2.47 mGy for breast thicknesses between 55 and 65 mm, similar to values reported in regions such as Europe, North America, and Asia (10). All reported values are below the established diagnostic reference levels (DRL) (11).

In conclusion, the use of DBT with 2D synthesized images for breast diagnosis does not represent a significant increase in radiation dose for patients and provides greater diagnostic value compared to conventional mammography.

Limitations

Exclusion of patients with breast prostheses: The exclusion of this group reduces the representativeness of the study, since patients with prostheses constitute an important percentage in breast diagnostic clinics. Future research should include this group to provide a more complete evaluation in different anatomical contexts.

Recommendations for future studies

Dosimetric assessment in complementary procedures: Include dose measurement in complementary tomosynthesis procedures, such as biopsies and marker placement, to analyze the dosimetric impact on the comprehensive management of patients.

Cumulative dose analysis: Conduct longitudinal studies to assess cumulative dose in patients undergoing multiple diagnostic procedures over time.

References

1. Rafferty EA, Park JM, Philpotts LE, Poplack SP, Sumkin JH, Halpern EF, et al. Diagnostic accuracy and recall rates for digital mammography and digital mammography combined with one-view and two-view tomosynthesis: Results of an enriched reader study. Am J Roentgenol. 2014;202(2):273-81.
2. Gilbert FJ, Tucker L, Gillan MGC, Willsher P, Cooke J, Duncan KA, et al. Accuracy of digital breast tomosynthesis for depicting breast cancer subgroups in a UK retrospective reading study (TOMMY Trial). Radiology. 2015;277(3):697-706.
3. Houssami N. Evidence on synthesized two-dimensional mammography versus digital mammography when using tomosynthesis (three-dimensional mammography) for population breast cancer screening. Clin Breast Cancer. 2018;18(4):255-60.e1.
4. ICRP. Diagnostic reference levels in medical imaging. ICRP Publication 135. Ann. ICRP. 2017;46(1).
5. Feng SSJ, Sechopoulos I. Clinical digital breast tomosynthesis system: Dosimetric characterization. Radiology. 2012;263(1):35-42.
6. James JR, Pavlicek W, Hanson JA, Boltz TF, Patel BK. Breast radiation dose with CESM compared with 2D FFDM and 3D tomosynthesis mammography. Am J Roentgenol. 2017;208(2):362-72.
7. Gennaro G, Bernardi D, Houssami N. Radiation dose with digital breast tomosynthesis compared to digital mammography: per-view analysis. Eur Radiol. 2018;28(2):573-81.
8. Skaane P, Bandos AI, Gullien R, Eben EB, Ekseth U, Haakenaasen U, et al. Comparison of digital mammography alone and digital mammography plus tomosynthesis in a population-based screening program. Radiology. 2013;267(1):47-56.
9. Díaz Henao F. Determinación de niveles de referencia en procedimientos de mamografía digital tomosíntesis [Tesis] Universidad Nacional de Colombia [internet]. 2020 May 23 [citado: 2023 may 15]. Disponible en: https://repositorio.unal.edu.co/handle/unal/77555
10. Suleiman M. Diagnostic reference levels for digital mammography in Australia [Tesis]. The University of Sydney [internet]. 2018 [citado: 2023 may 15]. Disponible en: http://hdl.handle.net/2123/18930.
11. Olgar T, Kahn T, Gosch D. Average glandular dose in digital mammography and breast tomosynthesis. Rofo. 2012;184(10):911-8.

Correspondence

Nathaly Barbosa Parada
Carrera 14 # 169-49
nbarbosa@fctic.org

Received for evaluation: December 5, 2023
Accepted for publication: December 15, 2023