Optimizing Exposure Parameters in Digital Mammography: A Study in Morocco

Talbi Mohammed, Oustous Aziz, Ben Messaoud Mounir, Sebihi Rajaa, Khalis Mohammed

***Abstract*—**Background: Breast cancer is the leading cause of death for women around the world. Screening mammography is the reference examination, due to its sensitivity for detecting small lesions and micro-calcifications. Therefore, it is essential to ensure quality mammographic examinations with the most optimal dose. These conditions depend on the choice of exposure parameters. Clinically, practices must be evaluated in order to determine the most appropriate exposure parameters. Material and Methods: We performed our measurements on a mobile mammography unit (PLANMED Sofie-classic.) in Morocco. A solid dosimeter (AGMS Radcal) and a MTM 100 phantom allow to quantify the delivered dose and the image quality. For image quality assessment, scores are defined by the rate of visible inserts (MTM 100 phantom), obtained and compared for each acquisition. Results: The results show that the parameters of the mammography unit on which we have made our measurements can be improved in order to offer a better compromise between image quality and breast dose. The last one can be reduced up from 13.27% to 22.16%, while preserving comparable image quality.

***Keywords*—** Mammography, image quality, breast dose.

I. Introduction

NOWADAYS, breast cancer is the most common cancer and the second leading cause of cancer death among women. It accounts for 16% of all women's cancers [1].

In Morocco, between 30 000 and 40 000 new cases of cancer are identified each year, the most frequent localization, on the women's list, is the breast cancer which occupies the first place (36%) [2]. The chances of winning the battle for healing are the result of the progress made in this direction through multiple actions supported by the Ministry of Health, through awareness campaigns and mobilization in early detection [3].

The Ministry of Health proceeded a screening mammography program, for women over 45 years, using mobile units [4], [5]. Breast cancer screenings are recommended once every 2 years for women aged 45 to 70 years.

One of the risks of the screening is radiation-induced cancers. For 100,000 women, aged 40 to 55, each receiving a dose of 3.7 mGy on both breasts and examined every two years until age 74, it is expected that 86 cancers and 11 deaths from radiation-induced breast cancer will be induced. [6], [7].

For a woman considered to be at risk [8], not counting other examinations (computed tomography, radiology) [9], she can undergo more than 20 mammographic examinations during her life, that count multiple shots, so she receives repeated doses over a short period of time. [10]

Ensuring optimization of image quality and minimizing breast dose in mammography patients is a major challenge. Several research works concluded the impact of exposure parameters on the quality of image and dose radiation. It tried to suggest standards for imaging protocols that balance the image quality and the dose [11]. Therefore, it is essential to ensure quality examination with the lowest possible dose. These conditions depend on the choice of parameters (anode/ filter, voltage and tube current). Clinically, the majority of radiology technicians use the automatic pre-programmed mode on the device.

The purpose of our research is to verify that these constants are adapted. Using the manual mode and varying one parameter at a time, we were able to determine the most appropriate anode/filter, voltage and tube current.

II. Material and Methods

We performed our measurements on a mobile mammography unit in Morocco (PLANMED:Sofie-classic). To assess the image quality and the breast dose, we relied on the European protocol for the quality control of the physical and technical aspects of mammography screening. [12].

For image quality assessment, we used MTM100 phantom: an artificial breast designed and dedicated to the performance test of a mammography machine. It contains:

- Micro-calcifications.
- Masses
- Fibrous structures

Scores are obtained by the rate of visible inserts (MTM 100 phantom), and compared for each acquisition both in manual (kVp, the tube current, the anode / filter couple) and automatic mode (AEC).

The MTM100 phantom is placed between the compression plate and the breast position base. Symmetry must be achieved between the two sides of the phantom with the help of the cells drawn in the compression plate, to avoid slightly oblique images. This may subsequently cause a lack of occurrence of expected masses due to misposition. After taking the images, the cassette is injected into the digitizer, whose function is to extract the image obtained for diagnostic purposes.

For the evaluation of the glandular dose, we used a small solid state multi-parameter sensor (The AGMS-M+

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Multisensor) used for single exposure. It measures dose, dose-rate, time, and kVp, HVL, and beam filtration. We also used The Rapid-Gold digitizer through its Accu-gold software that allows to visualize the result obtained.

We have been able to compare the different modes of exposure. First, we exposed the detector by the automatic exposure control (AEC), then we exposed the detector by the manual mode by varying one parameter at a time (kVp, the tube current, the anode/filter couple).

The value of the current of the tube (mAs) is fixed (there is a stability of the image quality for the mAs between 32 and 40, then a slight improvement for the range (70-80 mAs)) and the kilo-voltage is varied (between (26-32 kV)).

In order to obtain a close estimate to the real case, the detector was placed directly on the MTM 100 phantom, to take into account the effect of the back-scattering factor. The effect of tube current (mAs) was neglected.

Score calculation: The image quality is expressed by a calculation of score, obtained by the summation of the number of lesions appearing in the image taken at the end of the MTM100. Generally, the quality improves in parallel with the increase of the score and vice-versa.

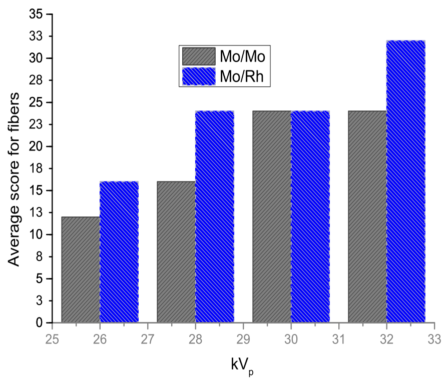

Fig. 1 kVp vs. score of fibers

III. Result

A. Image Quality

In this study, we carried out several manipulations to evaluate the image quality according to the exposure mode for the two combinations anode-filter: Mo /Mo and Mo/Rh.For each group of micro-calcifications, masses and fibers, the number of inclusions is determined. The last visible inclusion gives the score.

We evaluate the degree of inclusions' visibility: entirely or partially visible the overall score is the sum of the partial scores. On Fig. 1, we tried to compare the image quality via the score obtained for fibers. We used the manual exposure mode, varying the kVp voltage for four different kVp values (26, 28, 30, and 32), while the tube current remained fixed. For this manipulation, the score of fibers element increases from low voltage to 32 kV peak voltage. The score was better for Mo/Rh than Mo/Mo. Fig. 2 represents the calculated score variation for the two anode-filter pairs for masses visibility.

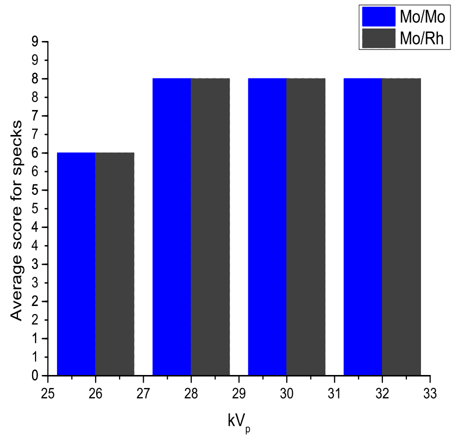

Fig. 2 kVp vs. score of specks

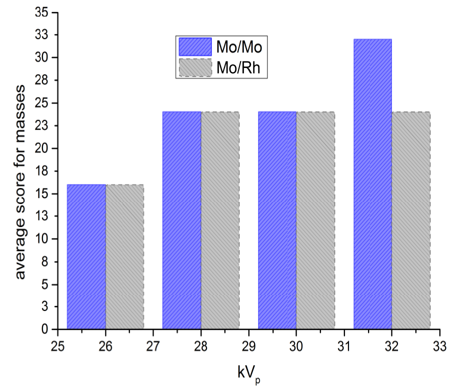

Fig. 3 kVp vs. score for masses

In terms of the score of masses, it was the same for both target-filter combinations at kVp 26-28, with slight increase with Mo/Rh at 32 kVp. Fig. 3 demonstrates a comparison of the image quality between Mo/Mo and Mo/Rh for the visibility of specks against the tube voltage (kVp). A significant increase was observed for both combinations at 28 kVp, and no changes were observed between 28 and 32 kVp.

We summed the total scores of the inclusions, and we observed that the score increases with the increase of the voltage with a slight domination with the couple Mo/Rh than with the couple Mo/Mo this variation is shown in Fig. 4. The result of this manipulation shows that the score is greater than 56 (1 SD) which shows that the device is in the standard recommendations and that the score of acceptability is 32.

At the end of the manipulations, we have chosen to compare the manual exposure mode and the automatic mode for the same device for the same combinations and for similar peak voltages. For the 32 kVp voltage, the two modes are in the norms since the acceptability score is 32, while the two modes are around 64 (1 SD).

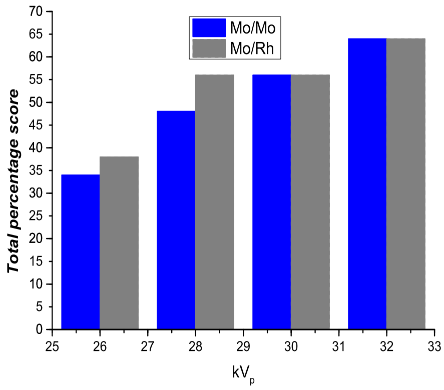

Fig. 4 kVp vs. total inclusions score

B. Radiation Dose

At the mobile unit, experimental measurements were realized to evaluate the image quality and the level of exposure. At the beginning for each peak voltage of the range (26-32) kV and for each anode-filtration pair selectable on the device, the dose at the input was raised by incrementing successively. In Fig. 5, we mentioned the dose at the input as a function of the voltage kVp for the two filter-anode couples.

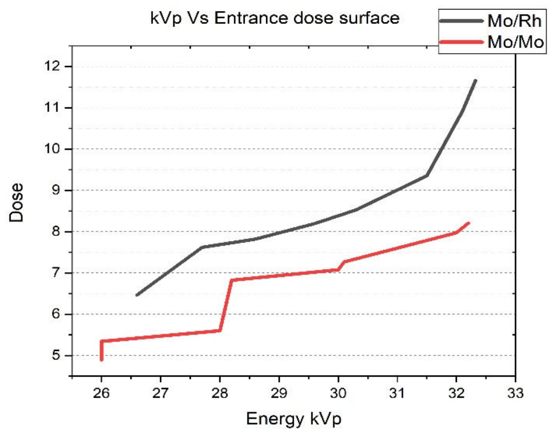

Fig. 5 kVp vs entrance dose surface

We found that the dose at the input increases significantly by increasing the voltage kVp. Examination of these two acceptability criteria makes it possible to show that the beam is in agreement with the standards.

The dose increases significantly with the voltage and it varies between 2 mGy and 8.21 mGy for the Mo/Mo couple, and between 6 and 10.32 mGy for the Mo/Rh. When using the automatic mode, the dose is around 10.03 mGy for Mo/Mo and 11.69 mGy for Mo/Rh.

Comparison between manual mode and automatic mode for the anode-filter pairs shows that the dose at the entrance for the automatic mode is higher compared to the dose in manual exposure mode.

IV. Discussion

A. Image Quality

The facility is within the norms, since the acceptability criterion is 32, while the results obtained for both exposure modes are generally around 56 (1 SD) except for low voltage. The analysis of the curves obtained led us to deduce that the image quality increases as a function of the voltage kV.

Noel et al. realized the same tests on several facilities in France, with the MTM100 phantom using only the automatic mode. They found the mean image quality score value (limiting value = 24) was 34 (1 SD) [13].

There is a stability of the image quality for the kVp between 30 and 32 for masses and specks, then a slight improvement for fibers. The results of Williams et al. indicated that higher tube voltages would produce no further performance improvement for a given phantom type [14]. For this reason, we must understand the relationship between radiation dose and image quality [15]. It is obvious that the image quality progresses significantly with the increase of the exposure parameters but we must not neglect the dose that progresses with it. So, we must look for the image that delivers the best quality with the lowest dose.

The purpose of the optimizing techniques is to establish standards for imaging protocols that balance the image quality and the dose to the patients [16].

B. Radiation Dose

A comparison between the two pairs shows that the Mo / Rh pair is more irradiating than the Mo / Mo pair. For the manual exposure mode, the dosimetric quantities are optimal while being based on the annual regulatory limits of the CIPR [17] in its publication 103 (From <10 mGy), and the entrance surface dose in the automatic mode was around 10.03 mGy for Mo/Mo and 11.69 mGy for Mo/Rh which mean is in the limit of desirable value.

If we compare our results with those of Noel et al., using the mode AEC, they found in the majority of facilities that the mean dose value (limiting desirable value = 10 mGy) was 8.6 mGy (1 SD) [13], while our results were slightly higher.

We were in the range of results of Bor et al., using MTM100 phantom and CIRS phantom measured ESAK (Entrance surface air KERMA) values (can be considered equal to entrance surface dose) using the routine clinical exposure settings. The mean ESAK value was 10.1 mGy, with a range of 3.78–17.8 mGy for the CIRS phantom. The results of the four systems were not within the proposed tolerances. [18]

The optimization of the mammography technique should not be limited to dose reduction, but to reduce the dose and to look for an image which allows to make the correct diagnosis. [19]. The entrance surface dose can be reduced up to 22.16% for Mo/Mo and 13.27% for Mo/Rh couple, while preserving comparable image quality.

We have concluded that for a breast thickness of less than

45 mm, the filter/anode Mo/Mo pair is well adapted with a voltage between 28 and 30 kVp. It is slightly the same for Alkhalifah et al. and Chien-HauChu et al.: for each breast thicknesses of 21 mm or 32 mm, a voltage of 25 kV or 28 kV and a target combination Mo/Mo/filter was optimal and for 40 mm thickness and over a voltage of 30-32 kVp and a target filter combination of Mo/Rh was recommended [20], [21].

V. CONCLUSION

The measurements of image quality and the entrance surface dose were made on a mobile mammography unit in Morocco. The results showed that the acquisition parameters can be improved to optimize the dose to patients and can be reduced up to 13.27% to 22.16%, while preserving comparable image quality. The objective of optimizing the radiological techniques is to standardize the protocols that balance the image quality and the dose received by the patients. In order to improve the functioning of the facilities in Morocco, a quality control program should be applied periodically and the diagnostic reference levels (DRLs) established.

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