Evaluation of radiation doses resulting from the use of x-rays in mammography

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Abstract
Breast cancer threatens a large proportion of the world’s women to die annually and does not know the exact causes of this disease. Among these causes is an increase in the surface radiation dose absorbed by the breast during the examination. The research included estimating the ESDpp surface admission dose in the presence of the patient as well as measuring the ESDpa surface entry dose by the absence of the patient and the same previous conditions of voltage and exposure (mAs), background scattering factor for the rays, and calculating the glandular dose rate (AGD) after finding the value of the conversion factor appropriate to the test conditions given in the standard tables (Ec. 1996a), quality assurance measurements. The study was conducted in Baghdad Teaching Hospital and Alzafaranya Hospital using two advanced Giotto devices, and it included a number of patients (20 patients) by (10 patients) in each hospital and used compressed breast thickness (CBT) of 60 cm, 70 cm respectively in each of the two sites. The study showed that the maximum values of the ESDpp and ESDpa surface admission dose measured using the (Dosimax) device and the ionization chamber, respectively, do not exceed its value (21mGy). The mean glandular dose rate AGD, the maximum values are (4.1mGy).

INTRODUCTION
Mammography is a special type of imaging in which the radiation dose is relatively low. Also, breast imaging plays an important role in the early diagnosis of breast cancer two years before the patient's symptoms appear.
When there is an anomaly in radiography (i.e. abnormal cases during mammography) many pictures are taken of it for study of patients or for more accurate diagnosis where the sample is taken and enlarged for easy identification.
There are two types of breast tumors are benign and malignant and it was noted that 80% of the tumors examined under a microscope are benign tumors (1995LAW J).
Breast consists of three types of tissues: fibers, glands and fat. After a woman reaches 20 years old, grease in the breast increases and fibrous glands are generated and are sensitive to cancer recovery by radiation, which leads to obtaining deformation in the connective tissue and ducts,

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so imaging should be Radial is a high-tech technique in which low voltages are used to increase the contrast between breast tissue, to reduce the penetration of rays into it, and it also increases the amount of exposure mAs (current * time).

**Breast imaging benefits:**
1- It allows the radiographer to be able to identify small tumors when the cancer is at the beginning and in this case the possibility of recovery is great.
2- Relying on screening mammography increases the detection of tumors or abnormal growth of small tissues present in the breast tissue, especially in the milk channels in the breast, which are called (ductal carcinoma in situ) These early tumors do not harm the patient if they are removed at this stage. Breast imaging is the only way to diagnose these tumors. (1995LAW J)

**Photography risks:**
1- The effective radiological dose resulting from mammography (about 0.7mSv) is equal to or equal to the dose a person receives from the background during three months (2002 Fujisaki). Therefore, all imaging devices must be subject to annual monitoring by a medical physicist mediated by Medical Physicist each year (2002 Fujisaki).
2- The woman should see a doctor to confirm that the affected tumors are still benign.
3- Sometimes breast imaging is difficult because the normal breast appears different each time.
4- In breast imaging, multiple images must be compared with each other because breast cancer is sometimes difficult to see. The radiator needs to be compared to the previous pictures.

**MATERIAL AND METHODS**

1- **Breast Imaging System and Accessories:**
The use of two devices, Giotto type, the Italian origin, for imaging the first breast, is present in the Baghdad Teaching Hospital and the other in the Alzafaranya Hospital because of the good advantages it enjoys, as it gives a high-quality image and exposes the patient to the lowest possible radiation dose as it is easy to use and allows the patient to be in complete comfort While using it because it is lying on examination and relaxed, the flat position of the patient helps to examine a small sample of the breast tissue as in Figure (1-1) and Figure (1-2). This device consists of the following parts:

1) X-ray Generator:
   A- With single phase, high frequency, and organized microprocessing.
   B- Voltage from (22-35) kV per step 0.5.
   C- The exposure is from (4-600) mAs.

2) x-ray tube:
   A- a rotating anode (9000 or 3000 RPM).
   B-Anode of Molybdenum anode.
   C- Focal spot size 0.1 / 0.3nm.
   D- Filter: Rh 0.025mm / Molybdenum 0.03mm. (Automatic and manual design).
   E- Control the operation of the tube automatically or manually.

**Features and vocabulary of the device:**
1. A vertical movement with a distance of 60 cm using a motor that runs automatically.
2. Circular motion at $135^\circ + 180^\circ$ automatic.
3. Automatic tilt $\pm 90^\circ$ automatic.
4. The distance between the device and the film (SID) = 60 cm.
5. Bucky Grid The filter ratio is 5: 1 or 31/ cm and coincides with the speed.
6. 1.5X and 1.8X magnification automatically.
7. Manually and automatically compress the breast.

Breast pressure device

Among the accessories of the imaging device is a breast compression machine, which is a rigid pressure unit that is parallel to the surface of the image receiver, as shown in Figure 3. Breast pressure is necessary for mammograms to obtain a high-quality mammogram, and the pressure is manually or self-moving, and the pressure on the breast must be as much as the patient can bear.

The process of breast compress is very necessary for the following reasons: -
1. To obtain equal thickness and spread the tissue to clarify any small defect that may be hidden by the surrounding breast tissue.
2. We use the lowest possible dose, as a result of obtaining the lowest possible thickness of breast tissue.
3. Maintaining the firmness of the breast, to avoid any blurring or any distortion in photography resulting from movement.
4. Reduces scattered radiation, thus obtaining a good quality image (2003 Jamal).

It is known that breast pressure is the biggest obstacle to the patient when photographing the breast, and certainly during imaging there are all different sizes of the breast, density, durability, strength of cohesion, and sensitivity to pain, in this case the pressure device puts all these factors into account and deals with the patient where he feels With minimal pain, the pressure plate is in contact with the breast. In this case, the pressure stops for about half a minute, after which the pressure is slowly returned to suit the sensitivity of the breast and without pain as much as possible.
2- Unfors Instrument
This Swedish-made device consists of a detector that has an ionization chamber connected to a coated wire connected to a digital counter. The principle of this device's work is to collect electrons on the anode as a result of the fall of X-ray photons on the cathode. The device is designed for quality assurance tests as it measures the dose, time, dose rate and voltage directly.
The most important features of this meter are its small size, accuracy in measurement, and the figure (4) shows a picture of the Unfors mobile device.
3-Dosimax:

**Application** QA measurements at mammographic units, (DOSIMAX - detector DEMX)

**Features**

- high dynamic auto range / auto reset
- extension cable (7 m)
- microprocessor based circuits
- power: 9 V alkaline or rechargeable battery
- auto shut - down after 5 minutes inactivity
- built - in test function permits verification of operation
- alphanumeric high - contrast 8 - segment liquid crystal display
- automatic detection of operating mode (exposure or fluoroscopy)
- temperature range: 15°C to 30°C (operating) 0°C to 50°C (storage)
- size and weight: 196 * 100 * 40 mm / 0.4 kg

Figure (5) represents the image of the Dosimax device
4- Dosage scale using TLD flash tablets:
The TLD dose gauge was used in this research to measure the incoming surface dose of examined people by placing this scale on the examined patient's breasts to measure the incoming surface dose.
The TLD consists of lithium fluoride (LiF) with Teflon added to protect it from external exposure. It is in the form of small discs, each disc thickness (0.4 mm) and placed inside a thin plastic sheet impermeable to light (2003 Tohno).
This scale has been chosen for the following reasons: -
1. Lithium fluoride has an atomic weight roughly similar to the atomic weight of human tissue. Thus, the energy absorption is almost identical to that of the tissue (a tissue-equivalent material).
2. The ability of this scale to measure a wide range of doses (10^2-10^-4 Gray).
3. The response does not depend on the dose rate. Also, the response change is linear with the dose up to about (1 Gray).
4. Little change in sensitivity with radiant energy.
5. Easy to use and read very accurately. It can also be read automatically in the TLD reader device.
6. The use of this scale does not affect the resulting radiogram.
7. It can be plasticized and reused dozens of times with very little change in efficiency, so it is economical.
8. Not affected by humidity and temperature.
Some crystalline materials possess a thermal glow property, that is, they emit photons by way of heating after exposure to these rays called (Thermo luminescence) and that the amount of light emitted from these materials is proportional to the amount of dose absorbed as a result of radiation exposure. The use of this phenomenon in determining and measuring radiation doses is called the TLD dose scale. Crystalline materials have a regular crystalline structure, but by adding some impurities to it, they cause an imbalance in this structure and the deformations appear in the crystal system of the crystal. When exposing this crystal to ionizing radiation, it absorbs part of its energy, and this results in the release of some electrons from the valence band and reaching the conduction band, leaving behind the gaps in the valence band. However, most of these electrons soon return and combine with the gaps and return to the stable state, while the rest of them are hunted in traps at the (semi-stable) levels. It remains at these levels for some time depending on the temperature of the crystalline substance. The constant heating of this material increases its temperature and leads to the release of electrons from their traps and their elevation to higher levels and back from there again to the stable state with the emission of light.
The wavelength of the emitted light is a distinctive property of the crystalline material and the impurities it contains. The total amount of emitted light is proportional to the number of traps, and the irritated electrons, and thus to the amount of energy absorbed. As for the intensity of the light emitted by the material, it is proportional to the radiation dose (Radiation Dose).
The graphical relationship between the intensity of the resulting light, time, or temperature is known as (the flare curve), as this curve is a characteristic of the phosphorous material, so it is used to measure the radiation dose by calculating the area under this curve or peak height. (Tohno)
There are a number of tainted flashing materials by which radial doses received by means of thermal flash can be measured, and these materials are CaSO4, 6LiF, 7LiF, LiF-100. These materials can be manufactured in the form of different shapes and sizes and according to the conditions appropriate for measurement, since TL-dosimeter materials consist of a substance A crystalline or polycrystalline substance is tainted with a suitable activator such as Dy and Tm. The effect of the thermal flashing process is the presence of Electron Traps, Holes as a result of the presence of chemical impurities (2003 Tohno).

**Thermal flash system (Cale Reader (TLD))**:  
Use the Toledo TLD Reader to read and calibrate the TLD as in Figure (6), Figure (7), as this device is distinguished by the following:

1. Its high sensitivity to measure light from TLD.
2. Subtract the back reading of the scale automatically from the reading that the device gives.
3. A system for controlling and programming the heating cycle in terms of time, temperatures, cooling rates and required heating as well as programming the annealing process to obtain a constant sensitivity.

The thermal flash tablets are prepared, that is, the process of removing the effects of previous doses by heating it with a special device (Annealing Facility) and at specific temperatures within the cleaning cycle, up to the lowest value of the radiation background of these samples (Pellets) has been used temperature (300-400) degrees Celsius For an hour then several hours at a temperature of 80 degrees Celsius, depending on the type of material used. The following are the stages of heating:

1. Pre-heat cycle: 120 ° C
2. The measurement and reading cycle varies according to the type of sample (read - cycle) 250250 C.
3- Cleaning cycle (anneal - cycle) (300-400) c
4- Cool period (2003 Tohno).

**Patient preparation and preparation for imaging:**

Before starting the imaging, the doctor must be familiarized with the symptoms of the disease and the problems surrounding it. The patient must also tell the doctor everything about the diseases that she had previously suffered. The following recommendations must be followed:

1. Do not put a perfumed cream or cream under the armpits or on the breasts because they show points similar to calcium deposits on the image.
2. Clarify the symptoms and problems of the radiographer.
3. Bringing the previous examinations for mammography when performing the current examination.
4. Remove all jewelry, jewelry, and clothing from above the chest when photographing.
5. Avoid imaging the breast a week before the session, especially if the breast is painful and the appropriate time is considered the most appropriate time to perform the imaging process and a week after the end of the menstrual cycle to take the imaging a week after the session.

And then the process of breast imaging is done by placing it on the surface parallel to the surface of the image receiver after applying it with a certain cream and then compressing it comfortably and gradually so that it does not harm the patient because the breast pressure process is very necessary to obtain equal thickness and make the optical density of the image homogeneous and thus reduce the dispersed dose and X-ray as in Figure (7).

This process takes place within half an hour until the patient receives the result from the doctor.

![Figure (8) breast imaging device showing the steps of preparing the patient](image-url)

**Measurement of radiation dose (surface dose):**
The practical method that was followed to calculate the radiation doses resulting from radiation exposure during a mammogram examination is:

A- Calculating the ESDpp surface dose in the presence of the patient using thermal flash flash TLDs by placing these tablets in black nylon bags and then placed on the patient's breasts under the site of radiation. The use of this method does not require any prior measurements except that the resulting beam energy (kVp) and the exposure amount (mAs) must be known.
We choose 20 patients with a mammary thickness of 6-7 cm and after TLD irradiation the last one is taken to the laboratory to find out the dose amount.

**Calculate the ESDpa surface dose using the ionization chamber of the Unfors device.**
The Unfors device is placed in a disk position (TLD) under the same conditions of the amount of kVp and the exposure value mAs. After the device is exposed to the same previously measured dose, press the power key to give the dose amount, and then press second, and we get the dose rate amount (mGy) / (mA) as well as we press again to get the time.

**Measurements:**
The measurements were made at Medical City Hospital and Alzafaranya Hospital, and include radiometric dose and quality control measurements, which include the results of radiological tests and discussion of the results.

**Radiation portions:**

1- **Radiation dose measurement in the presence of the patient:**
ESDpp was measured using a Dosimax device. After the results were obtained, the values were calculated according to the average values and compared with the standard value.
A medical diagnosis was made for (20 patients), a compressed breast thickness of 6 cm in Medical City, and a compact breast thickness of 7 cm in Alzafaranya Hospital.

2- **Measuring radiation doses when the patient is not present and measured using the Unfors ionization chamber.**
Surface entry doses were measured using the ionization chamber when the patient was not present under the same previous conditions of exposure and voltage value (mAs) and voltage (kVp). These checks were performed in both the Teaching Hospital and the Alzafaranya Hospital.

3- **Calculation of posterior scattering factor (G)**
According to the scattering factor, dividing the surface admission dose when the patient is present (ESDpp) by the surface admission dose when the patient is not present (ESDpa) and Tables (1) (2) illustrate the readings and results obtained when performing the previous measurements at the City of Medicine Hospital, And Alzafaranya Hospital.

**Table (1) readings were measured in Medical City Hospital**

| NO. | kVp | mAs | ESDppmGy | ESDpamGy | Sec. (s) | G     | AGDmGy |
|-----|-----|-----|----------|----------|---------|-------|--------|
| 1.  | 25  | 3   | 0.977    | 0.85     | 0.40    | 1.15  | 0.1462 |
| 2.  | 25  | 42  | 7.8      | 6.93     | 0.837   | 1.09  | 1.1919 |
| 3.  | 25  | 108 | 19.97    | 19.02    | 1.337   | 1.05  | 3.2714 |
| 4.  | 25  | 186 | 26.75    | 25.8     | 1.492   | 1.07  | 4.4376 |
| 5.  | 26  | 59  | 11.876   | 10.51    | 0.923   | 1.13  | 1.8077 |
| 6.  | 30  | 60  | 17.37    | 15.11    | 0.921   | 1.2   | 2.5921 |
| 7.  | 28  | 30  | 9.8      | 9.005    | 0.622   | 1.2   | 1.5480 |
| 8.  | 28  | 50  | 11       | 9.005    | 0.65    | 1.22  | 1.5481 |
| 9.  | 27  | 125 | 25.72    | 23.61    | 1.509   | 1.09  | 4.0600 |
| 10. | 27  | 120 | 25.27    | 23.40    | 1.455   | 1.08  | 4.02   |
Table (2) readings measured at Al Alzafaranya Hospital

| NO. | kVp | mAs | ESDpp | ESDPa | G  | AGD  |
|-----|-----|-----|-------|-------|----|------|
| 1.  | 27  | 30  | 3.851 | 3.469 | 1.11| 0.5030 |
| 2.  | 27  | 35  | 4.550 | 4.136 | 101 | 0.5997 |
| 3.  | 27  | 40  | 4.991 | 4.941 | 1.01 | 0.7164 |
| 4.  | 27  | 45  | 4.332 | 4.983 | 1.07 | 0.7221 |
| 5.  | 27  | 65  | 7.895 | 7.164 | 1.102| 1.0387 |
| 6.  | 27  | 70  | 8.88  | 8.222 | 1.08 | 1.1921 |
| 7.  | 27  | 75  | 9.501 | 8.483 | 1.12 | 1.2300 |
| 8.  | 25  | 90  | 11.01 | 10.0  | 1.101| 1.4501 |
| 9.  | 25  | 95  | 17.111| 15.415| 1.11 | 2.2351 |
| 10. | 25  | 100 | 15    | 14.563| 1.03 | 2.1020 |

Table (3) relationship of compressed breast thickness with dose and exposure

| Thickness (cm) | Dose mGy | AGD  |
|----------------|----------|------|
| 4              | 6.7      | 1.15 |
| 4.5            | 7.5      | 1.29 |
| 5              | 8.5      | 1.49 |
| 5.5            | 9.3      | 1.59 |
| 6              | 10.10    | 1.73 |
| 6.5            | 10.8     | 1.85 |

Discussion:
The types of X-ray diagnostic devices have varied recently, and their techniques and the way in which radiological examinations are performed and the exposure conditions used to conduct these examinations have varied, resulting in different radiation doses that the examined people receive from one device to another, even to the same type of radiological examination. We also note in Table (2) that the readings have a difference but do not exceed the standard limits except in the case of high exposure when there are cancerous diseases or telephones. This difference is not entirely due to the used devices, but is also largely due to inappropriate testing of exposure factors such as voltages, exposure time, appropriate filtration and package size, so any exposure that increases the radiation dose to the patient must be avoided without achieving the desired benefit from it, where the value of the dose applied to the patient decreases by increasing the specific control and quality control of the used devices. Likewise, the presence of this variation in the measured doses for the same checks in a number of hospitals, explaining that as a result of the position of the Dosimax device or the difference in the anatomical composition of the patients, or the engineering arrangement of the field of the X-ray beam and to reduce the degree of severity or some harmful effects, it should avoid any exposure from it would increase the patient's radiation dose.

Below is a discussion of Table (3) and (4)

1. The value of the radiation dose measured in mGy, that is, the surface incoming dose (ESDpp) experienced by the patient within the standard limits does not exceed 17mGy, but there are other values that exceed these values and reach 25mGy, and this is in the case of high exposure (mAs), where there are pathological conditions in the breast, which requires increased exposure. In this case, the patient is accompanied by harmful effects due to the increased dose,
which often causes breast cancer, and to reduce the harmful effects associated with diagnostic X-rays is to reduce the dose exposed to the patient, which is achieved by the development in operating equipment, and reduce the size of the exposed tissue using determinants, and reduce the number of times Examination and avoid repeating some radiographs, and choosing the appropriate exposure factors, knowing that the surface dose included gives an indication of the maximum dose that can be received by any cell from the body cells and various organs.

2. We note that the value of the ESDpp dose measured in (Dosimax) varies from one unit to another in the value of the measured dose and varies greatly from point to point on the breast, so that the maximum is possible in the area perpendicular to the main bundle while the other areas receive much lower doses and be resulting from scattered rays. For example, when placing (Dosimax) instead of the left breast and exposure is directly to the left breast and the other is placed on the right breast, we notice that the reading of the right breast is usually non-existent or very little, where its value (0.11mGy), which is about 100 times less than the left breast while the breast The left was reading it (9.038), as in Table (4) the following:

| kVp | mAs | EsDpp mGy Left breast | EsDpp Right breast |
|-----|-----|-----------------------|--------------------|
| 25  | 40  | 9.038                 | 0.110              |
| 25  | 60  | 10.320                | 0.113              |
| 25  | 75  | 12.012                | 0.1201             |

Table (4) shows the dose amount on the left and right breasts

This indicates that the radiation is focused on the site to be diagnosed, and that the development of the used equipment and the use of the grid and the beam automatically lead to a reduction of scattered radiation.

3. When kVp is established, an increase in dose at increased exposure (mAs) is observed.

4. We note that the ESDpa values are less than the ESDpp values measured under the same conditions (Dosimax), i.e. the same values for kVp and mAs, since ESDpa is defined as follows: It is the surface dose included indicating the maximum dose that any cell can receive without the contribution of posterior scattering.

Knowing the absorbed dose for the breast, especially the glandular dose (AGD), that is, the radiation dose absorbed in the glandular tissue, which is the best measure of the risk of radiation on the breast and the increase in it, causes cancer. It is at the forefront of the appropriate measurement of the breast dose. Therefore, we notice in Tables (1) (2):

1. We note that the AGD increases with the dose (EsDpa).
2. The highest value that the AGD reaches is (3 mGy) for breast examination. In return, the EsDpa value is within mGy (19-19), which in turn corresponds to the standard value as there are dose values in the aforementioned table above the reasonable limit. We have previously mentioned the reasons for this increase, among which there are pathological conditions in the breast that warrant high exposure.

From observing the result of measuring the radiation dose on the technical and medical staff, we find that the devices and equipment are highly technical, because the radiation value or dose is
very little or almost non-existent, so the rooms and locations near the X-ray machines for imaging the breasts are not dangerous as well due to the lack of radiation used which It makes their absorption easy.

Accordingly, the radiation dose was measured for the hospital staff and it was found that this dose is very small and is equal to 0.01 mGy / day and is within the limits of the radiation background.

It is noted that the value of the (posterior scattering) that we obtained is very close to the standard amounts that correspond to the thickness of the fair layer (HVL) as the standard value (1.1) taken from the source [EC.1999a] corresponds to 0.45 mmAl of the value (HVL) of the compressed breast, although The value we obtained was equal to 1.106, very close to the standard value in Madinah Medical City Hospital.

From observing the relationship between the dose and the thickness of the breast, it appears to us that it is a straight line relationship as shown in Table 1-2.

The increase in the thickness of the breast requires an increase in exposure as well as an increase in the dose, which leads to an increase in the glandular dose (AGD) and the fact that the hard compressed breast consists of dense tissue that is more difficult to influence the rays through it, and to obtain a good image we need higher energy and high exposure in the case Thick breasts as shown in Table (1-3).

It is also possible to mitigate the harmful effects associated with X-ray diagnosis by reducing the dose of the tissue whose radiation is exposed and obtained by:
1. Reducing the size of the exposed fabric by using special parameters.
2. Reducing the frequency of these exams and avoiding them again.
3. Selection of correct and appropriate exposure factors (2003 Fujisaki).

Unfortunately, the tests that are performed for the affected person with this disease are only to confirm that the tumors are malignant or benign and if the tumors are proven malignant then there is no drug treatment from this disease except eradication and attic each woman must follow that important part of her body and her life and make sure from time to time to notice signs of disease Breast cancer that is:
- Tumors or monolithic nodes of a solid texture differ from other tissues.
- Change in breast shape and color.
- bloody secretion in the nipple.
- Enlarged lymph nodes.
- Implantation of the nipple into the interior.

Breast cancer has become one of the main problems threatening the health of women in Iraq, after being subjected to tons of bombs and depleted uranium radiation in 1991 and beyond.

As there was a noticeable increase in breast cancer cases in recent years, there were 646 injuries recorded in the whole of the country in 1988, while recorded injuries in 1999 amounted to 1,304 injuries either in 2003, the Medical City received 1951 injuries and unfortunately, most
cases that It is often discovered in its late stages, which makes treatment difficult and may complicate the disease.
The spread of this disease is largely due to the lack of awareness among women, especially rural women, as a result of a clear failure by the Ministry of Health, which has not shown any media interest, especially as the country has come under the weight of pollution from one extreme to the other and in its three fields the atmosphere, the hydrosphere and the soil. (2000 Hammerstein).

CONCLUSIONS

1. It was found that the value of the Surface Entry Dose (ESD) when calculated by the TLD scale and the Unfors device is in conformity with the standard values (IAEA). Not exceeding 17 mGy
2. The glandular dose value (AGD) corresponds to the European standard value, which has a maximum value of 3mGy
3. The value of the posterior scattering factor ranges from 1.1 to 3 1. which corresponds to standard values.
4. The relationship between compressed breast thickness and exposure is linear.
5. The optical field corresponds to the radiant field exactly with the breast imaging devices.
6. The size of the radius focus falls within the good limits of dimensions, not breast imaging devices.
7. The relationship between the radiological dose (mGy) and the exposure rate (mAs) is a linear relationship where the linear coefficient does not exceed (1%) for mammography devices.

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