Calculation and Analysis of Mean Glandular Dose During a Mammogram

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Received: 20 Apr. 2014, Revised: 1 May 2014, Accepted: 3 July 2014
Published online: 10 September 2014

Abstract:

Mammographic density is the difference in appearance of glandular to fatty tissue in a mammogram. Investigation in doses delivered in mammography is carried out. The Mean Glandular Dose (MGD) is calculated and compared to the standard values. The results show the value of MGD is comparable to some of the references, however there are very large variations in MGD and mAs with respect to specific Compressed Breast Thickness and percent glandularity. The results suggest a lack of understanding of radiation uses and the risks that are involved in x-ray induced breast cancer in Sulaimani hospitals especially the Mammography Centre.

Keywords: Mean Glandular Dose (MGD) , Mammography, Radiation Dose in Mammograhy

Introduction

The causes and development of cancer is a complex process which involves a detailed study of risk factors, growth analysis, diagnosis, therapy, follow-ups, prevention and many other factors. Studying any one of these aspects and fields require interdisciplinary research and collaborations[10].

Mutations and irregular transformation in genes are one of the main causes of cancer. Generally healthy cells divide and replace themselves through an ordered process of cell growth and division. However in due course, mutation occurs and it can trigger certain genes and switch off others in a cell. This change causes cells to gain the capacity to keep dividing with no control or order, producing cells as it and forming a tumor.[10]

There are two types of tumors benign and malignant. Malignant cancer is potentially dangerous to health. Benign tumors consist of cells which have close similarity to normal healthy cell within a tissue, they do not attack close by tissues and therefore they do not metastasize. However malignant tumors are cancerous, if left unrestricted and untreated, they could ultimately spread away from the original tumor to other parts of the body.

Breast cancer refers to malignant tumors that are originated from cells in the breast. Typically breast cancer originates in the cells of the lobules (glands) or the ducts. Eventually, these cancerous cells attack healthy breast tissue found in close proximity and make their way into the lymph nodes found at the underarm, from there on they will have a passage to the rest of the body and hence spread throughout the body[10].

High number in reported cases and increased number of breast cancer has lead researchers to put more resources into investigation in the development and sources of breast cancer. Although many of these works are in their early stages, a recent work by researchers have developed an injection which could prevent breast cancer[3]. Unlike other cancer, progress in the field of breast

cancer investigation is slow. This is mainly due to the nature of this type of cancer which is intricate and involves many risk factors such as dependency on alcohol, smoking, age, geographical locations, family history, weight, race and many other factors. However one of the most important risk factors which is employed in radiography is the parenchymal pattern determined through a mammogram, where major and numerous studies has found a strong relation between these patterns and the possibility of breast cancer development[19].

The radiographic manifestation of female breast differs among woman of the same age due to variation in tissue composition [1].Breast density has been used to define (both quantitatively and qualitatively) the features of breast tissue as seen from a mammographic image[4]. Fat is radiographically lucent, it has a low attenuation coefficient and appears dark on mammogram; in contrast stromal and epithelial tissues are radiographically dense, they have a higher attenuation coefficient compared to fat and therefore appears light on the same mammogram. This appearance is referred to as mammographic density [5], and it is this difference in appearance that forms the bases of breast cancer diagnosis. Various studies have found strong relations between mammographic density and increased risk of breast cancer [9] [13] [18] [19]. Studies have shown females with density of 75% or more of overall volume of the breast are 4.7 times are more likely to develop breast cancer as compared to females with density of 10% or less of the same volume (95% confidence interval)[2].

Mammographic density measurement is therefore invaluable in the field of mammography, especially when it comes to early detection of cancer through mammographic density in which is currently employed worldwide in various screening program.

Despite these advantages, there are drawbacks related to density measurements. The level of accuracy is questionable, especially a study showed repositioning the breast causes the density to change from 27.6% to 13% when the female had two mammograms taken on the same day[12]. This is a reduction of more than 50% for the same patient. There is also the use of low energy ionizing radiation which is used as a standard for mammographic purposes. There is a small but significant risk of radiation induced carcinogenesis associated with the use of this low energy ionizing radiation.[8]. At present, it is thought that most vulnerable area within the breast is the glandular tissue[11], which they are potentially are at risk of induced cancer. To quantify and control this risk, Mean Glandular Dose (MGD) is calculated for each mammogram. Several works has proposed an establishment of Dose Reference Levels(DRL) within this field[17]. The aim of this work is therefore to calculate MDG for a mammogram for many patients who were visiting Sulaimani Hospital for diagnosis and screening purposes. Based on the outcome of this work, we try to establish if there is scientific grounds for the establishment of DRL in mammography.

Materials and Method.

At the Mammography Centre and Sulaimani Hospital, forthe period of 4 months, data on their GE SenographeEssential and Siemens 3000 Nova were recorded. The values of breast thickness and various parameters that are used during a mammogram such as exposure mAs, tube potential kV etc were measure. These are used with equation (1) to calculate MGD for the visiting patients.

$$MGD = K\ g\ c\ s \qquad (1)$$

Where MGD is the Mean Glandular Dose,K is the incident air kerma (in the

absence of scatter), g is related to a glandularity of 50%, the c-factor corrects for any difference in breast composition from50% glandularity and the s-factorcorrects for any difference due to the choice of X-ray spectrum due to anode/filter combination which aredifferent from Molybdenum/Molybdenum (Mo/Mo). These values are derived from Dance *etal*[5]–[7] and K is given by equation (2) :

$$K = O_d P_{It} \left(\frac{d_{sd}}{(d_{sd} - Tc)}\right)^2 \qquad (2)$$

$O_d$is the tube output, $P_{It}$is the tube current exposure time product (mAs)(also called Tube Loading), $d_{sd}$is the source-detector distance and T_c is the thickness of the compressed breast[11][14] [15]

Results and Discussion

During this research, data for 253 mammograms were taken from both Radiation Centre and Mammography Centre at Sulaimani Hospital. For all the mammograms, the anode/filter combinations were either Mo/Mo or Mo/Rh (Rhodium) this implies according to Dance *et al*[5], the values of s-factor are 1 and 1.017 respectively.

From Equation (1), the Mean Glandular Dose (MGD) in mGy was calculated and the result plotted against the compressed breast thickness (T_c) in cm as shown in Fig 1. A general trend of increasing dose as thickness increases can be observed, however this trend has some worrying results, and one such reading is the dose delivered for a thickness of 6 cm, which has a minimum at 0.396 mGy and a maximum of 5.130 mGy. This is an astonishing difference of more than 90% for the same breast thickness. This result not only applies to thickness of 6 cm but the same large difference between maximum and minimum dose for the same thickness has been observed for other Tc. These results are more easily shown in Table II.

These results are worrying in terms of Quality Assurance (QA) within the field of mammography. Not only these results show no compliance with a basic health and safety, they are also putting patients at risk with x-ray induced breast cancer.

When all patients are taken into account in this project, the average MGD was found to be 2.037 mGy, while the minimum and maximum dose were found to be 0.263 and 5.956 mGy respectively with a standard deviation of sample 1.415 mGy and standard error in mean (SEM) 0.09[20].

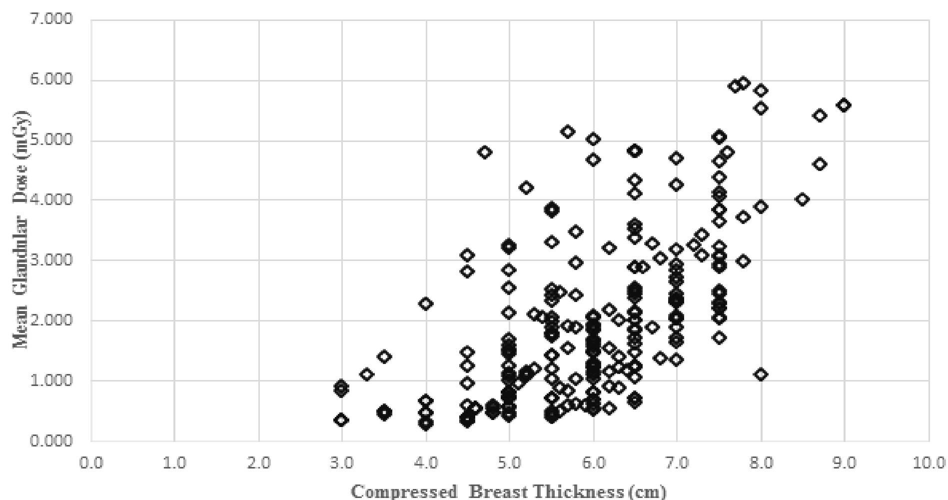

Fig. 1.: MGD variation with respect to Compressed Breast Thickness

In mammography, the x-ray machine setup is so designed that there is a very small variation in choosing different kV. This is mainly due properties of female breast tissue which are discussed in previous sections.The clinically useful range of kV are chosen to be between 25-32 and sometimes ±3 kV.

Table 1: MGD results compared to results from other work[+][16] and [++][8].

MGD (mGy) This work	MGD (mGy)[+]	MGD (mGy)[++] Various results
2.037	1.88	1.2 - 2.1

To determine and control the output of a mammogram in terms of contrast, tube loading setting is changed. The exposure is also linked to dose delivery and it is conventionally directly proportional with dose. Taking this relationship into account and the fact kV does not change very much, a graph of T_c and mAs should nearly be proportional. This means as T_c increases, so should the mAs, however Fig2 of thisresearch does not show this.There is a wide variation in the mAs change for the same T_c

Table 2: Differences in MGD for a given Breast Thickness

Mean Glandular Dose (mGy)			
Compressed Breast Thickness (cm)	**Minimum**	**Maximum**	**%Difference between Max & Min**
3	0.352	1.094	68
4	0.263	1.389	81
5	0.310	4.700	93
6	0.396	5.130	92
7	0.630	4.811	87
8	1.094	5.956	82
9	4.005	5.570	28

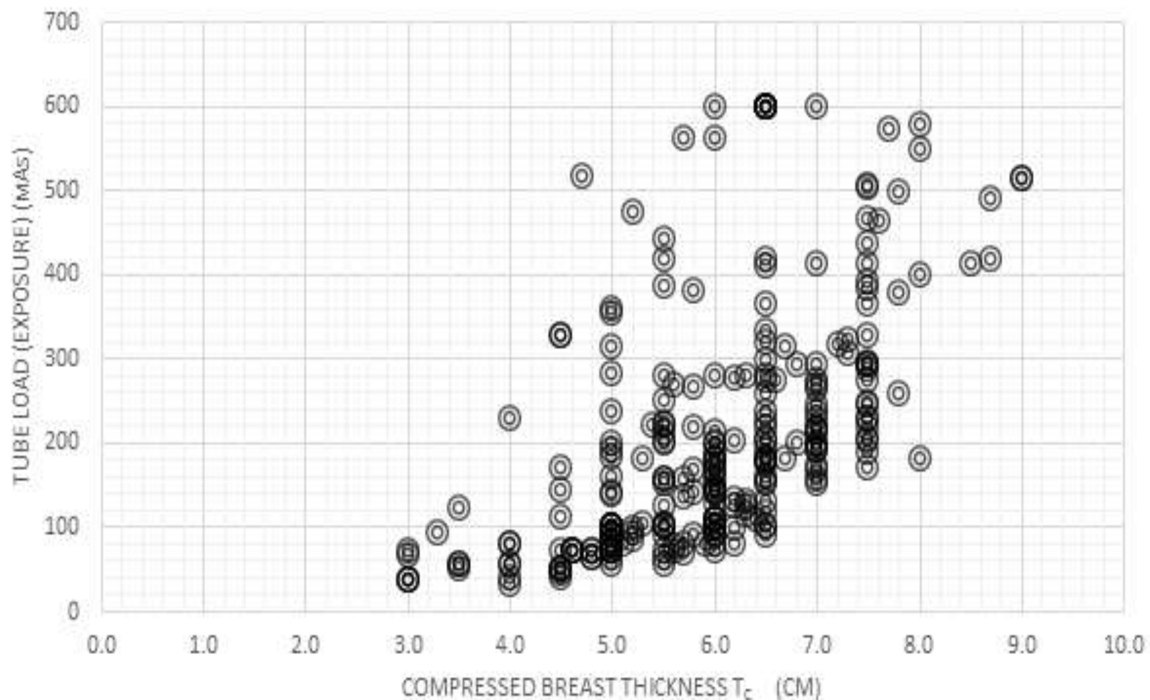

Fig. 2:mAs changes with incresed T_c

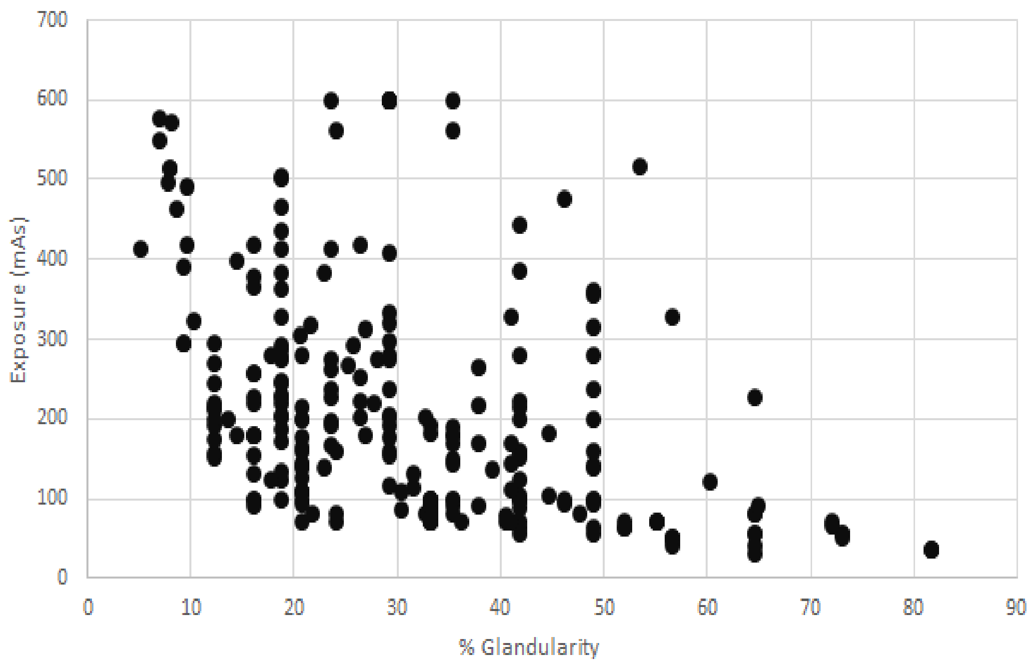

Fig. 3 : variation in mAs with % glandularity change

Just as the MGD, this implies the lack of understanding of these parameters by clinical staff who operate the machine. Percent glandularity (% glandularity) which indicates how much of the breast is made up of glandular tissue (which are vulnerable to radiation) is shown inprevious works to have a relationship with T_c. This relationship takes the form of[5]:

$$Glandularity\ (\%) = aT^3 + bT^2 + cT + d$$

Where a, b, c and d are coefficients and they are found in the same source above and T is the compressed breast thickness in mm.

Based on this information, one would expect to have an increased mAs as % glandularity increases.

When this analysis was carried out in this project, the result has found a near inverse of this.There is a general decreasing pattern of mAs as % glandularity increases although this decrease is inconclusive because there is no direct and clear relationship between the mAs chosen for a mammogram and the breast thickness. However just as in the case of MGD and mAs variation with respect to changing Tc, there is also a large variation in mAs for the same % glandularity. This large variation can clearly be seen in Fig 3.

Conclusions

In this work, we have calculated the Mean Glandular Dose (MGD) (mGy) for 253 mammogram from Sulaimani Hospital. We have found the MGD to have a higher value compared to some overseas results, except in one case where the result is comparable. This implies, in Sulaimani Hospital, an unnecessary higher dose is used in the field of mammography. Not only higher MGD is found in this work, an unjustified large variationof mAs, MGD is found for the same compressed breast and the % glandularity. This clearly shows clinical staff who are operating on the x-ray machine, have no or little understanding of the effect of increasing the mAs values on patient. This lack of understanding clearly puts patients at risk, especially the risk of x-ray induced breast cancer. Although one mightthink doses in the mGy ranges are too small to produce any accountable effect, there arevarious long term researches carried out which shows otherwise.

Recommendations

From these results, we strongly propose the establishment ofa local governmental committee to oversee the control of radiation within hospitals, to open courses and training for clinical staff so that they can understand the implications of various parameter changes on human health and finally the establishment of a local Dose Reference Level (DRL) so that when a particular level of dose exceeded, an investigation can be carried out.

Acknowledgements

The author would like to thank both undergraduate student: Dazhin Karwan and Shokhan Omer for participating in this project and for visiting the hospitals. The author would also like to thank the staffsat Sulaimani Hospital, especially the Mammography Centre and Mr. Ali Zuhdi for their kind assistance and support.

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