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Effective lifetime radiation risk for a number of national mammography screening programmes

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ABSTRACT

Background and purpose: The performance of mammography screening programmes is focussed mainly on breast cancer detection rates. However, when the benefits and risks of mammography are considered, the risk of radiation-induced cancer is calculated for only the examined breast using Mean Glandular Dose (MGD). The risk from radiation during mammography is often described as low or minimal. This study aims to evaluate the effective lifetime risk from full field digital mammography (FFDM) for a number of national screening programmes.

Material and Methods: Using an ATOM phantom, radiation doses to multiple organs were measured during standard screening mammography. Sixteen FFDM machines were used and the effective lifetime risk was calculated across the female lifespan for each machine. Once the risks were calculated using the phantom, the total effective lifetime risk across 48 national screening programmes was then calculated; this assumed that all these programmes use FFDM for screening.

Results: Large differences exist in effective lifetime risk, varying from 42.21 [39.12–45.30] cases/10^6 (mean [95% CI]) in the Maltese screening programme to 1099.67 [1019.25–1180.09] cases/10^6 for high breast cancer risk women in the United States of America. These differences are mainly attributed to the commencement age of screening mammography and the time interval between successive screens.

Conclusions: Effective risk should be considered as an additional parameter for the assessment of screening mammography programme performance, especially for those programmes which recommend an early onset and more frequent screening mammography.

Introduction

Breast cancer is a major public health concern and is the most frequently detected cancer among women in many countries.[1] It is the fifth largest cause of cancer death worldwide.[2] In 2012, breast cancer constituted 25% of new cancer cases in women and around 1.7 million new breast cancer cases were recorded worldwide.[3] Breast cancer morbidity differs significantly between regions and according to the American Cancer Society (ACS),[3] 39% of breast cancer cases were recorded in Asia while in Europe and North America, the figures were 28% and 15%, respectively. Early diagnosis and treatment of breast cancer is the key to reduce mortality.[4] Randomised screening trials using mammography illustrated that screening can reduce breast cancer mortality by 15–20%.[5] Since mammography is seen as a cost-effective technique for early detection of breast cancer, it remains the recommended modality for both screening and diagnosis.[6]

The performance of any screening programme should be assessed by three parameters; sensitivity, specificity, and positive predictive value.[7,8] The calculation of these parameters depends on three related quantities; mammography false negatives which represents mammography's inability to detect all breast cancers, mammography false positives which may result in extra examinations and undesired anxiety for women, and overdiagnosis of low risk breast cancers that may never cause health problems.[9,10]

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The most suitable measure of screening mammography benefit is the reduction in breast cancer mortality in women being screened compared to that in unscreened women.[11]

The risk-benefit argument resulted in the introduction of organised mammography screening programmes in many countries; though the recommendations for screening mammography are different among them in regards to the age of screening commencement and cessation age of the screens, and the time interval between screens (Table 1).[12]

The screening categories in Table 1 are recommended for average breast cancer risk women. High risk women include those with personal or familial history of breast cancer, or with mutations in breast cancer susceptibility genes BRCA1 and BRCA2, or with high breast density. Some of the mammography screening programmes exclude the high risk women and consider them as special cases, e.g. the Australian programme,[14] while other programmes have a specially designed screening category, e.g. the United States (U.S) and the United Kingdom (U.K) programmes which recommend early commencement annual mammography (Table 2). However, these strategies will result in an additional risk of cancer incidence due to radiation. Therefore some programmes use another imaging modality for screening, for example ultrasound or magnetic resonance imaging in addition to screening mammography.[15]

The risk of radiation-induced cancer from screening mammography has been considered small[17] and not included in the mortality assessment of screening programmes. This may be due to lack of availability of an accurate and reliable method to provide data about this risk. Therefore, within this study, the recently published method by M. Ali et al.[18] was utilised to evaluate the radiation risk from several national screening programmes using total effective risk during a female's lifetime. An assumption was made that all screening programmes would use FFDM for screening. The aim of this work was, therefore, to assess the radiation risk from FFDM screening for a number of national screening programmes.

Table 1
Illustrates the recommendations of mammography screening programmes in different countries for women with an average risk of developing breast cancer.[12,13]

Country(s)	Age of screening	Time interval between screens	Number of screens
Australia, Japan, Korea, United States (AAFP, NCI, and USPSTF)[a]	40–75	2 years	18
Belgium, Croatia, Cyprus, Denmark, Finland, Germany, Italy, Latvia, Lithuania, Luxembourg, Norway, Poland, Slovenia, Spain (Catalonia), Switzerland	50–69	2 years	10
Canada, France, Israel, Netherlands	50–74	2 years	13
China	40–59	3 years	7
Czech	44–75	2 years	16
Estonia	50–62	2 years	7
Hungary	45–65	2 years	11
Iceland	40–69	2 years	15
India	40–74	1 year (40–49) 2 years (50–74)	23
Ireland	50–64	2 years	8
Malta	50–60	3 years	4
New Zealand, Portugal, Spain (Navarra)	45–69	2 years	13
Nigeria	40–70	2 years	16
Sweden	40–74	18 months (40–49) 2 years (50–74)	19
United Kingdom	47–73	3 years	9
United States (ACOG)[b]	40–75	2 years (40–49) 1 year (50–75)	31
United States (ACS, ACR, and NCCN)[c]	40–75	1 year	36
Uruguay	40–69	2 years (40–49) 1 year (50–69)	25

[a] American Academy of Family Physicians, National Cancer Institute, and US Preventive Services Task Force.
[b] The American Congress of Obstetricians and Gynaecologist.
[c] American Cancer Society, American College of Radiology and National Cancer Comprehensive Network.

Table 2
Illustrates the recommendations of mammography screening programmes in different countries for women with a high risk of breast cancer.[15,16]

Country(s)	Age of screening	Time interval between screens	Number of screens
Canada	40–74	1 year (40–49) 2 years (50–74)	23
United Kingdom	40–73	1 year	34
United States (ACS)	30–75	1 year	46
United States (NCCN)	25–75	1 year	51

Method

An experimental approach was used to measure organs' doses using thermoluminescence dosimeters (TLDs) for standard four-view screening mammography. To achieve this, an adult ATOM dosimetry phantom and a bespoke breast phantom were used (Fig. 1). The absorbed dose for critical organs was measured for several different FFDM units. Dose data were used to calculate lifetime effective risk (equation (2)).

To simulate a women's body, an adult ATOM dosimetry phantom (CIRS Inc, Norfolk, Virginia, USA) was used. Within this phantom, there are detector holes in 20 radiosensitive organs. Manufacturer supplied breast attachments were used to simulate contralateral breasts each with a grid of holes inside to accommodate the dosimeters.[19]

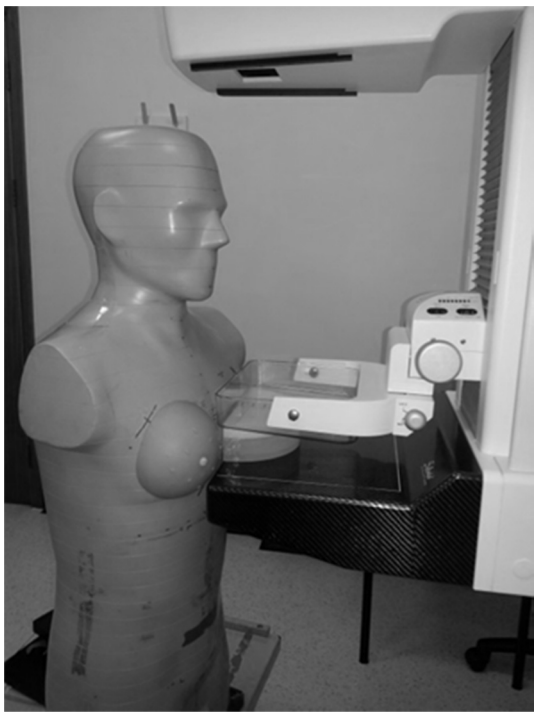

Figure 1. ATOM and breast phantoms positioned on a FFDM machine in the cranio-caudal (CC) position.

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