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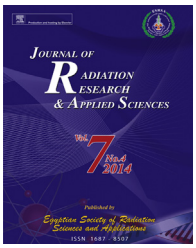

Determining the contralateral breast dose during radiotherapy of breast cancer using rainbow dosimeter

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ABSTRACT

External beam radiotherapy is being used regularly to treat the breast malignancy post-operatively. The contribution of the collimator leakage and scatter radiation dose to contralateral breast is of concern because of high radio sensitivity of breast tissue for carcinogenesis. This becomes more important when the age of breast cancer breast patient is younger than 45 years and therefore the contralateral breast must be treated as organ at risk. Quantification of contralateral dose during primary breast irradiation is helpful to estimate the risk of radiation induced secondary breast malignancy. In present study contralateral breast dose was measured in forty cancer breast patients undergoing external beam therapy by cobalt-60 teletherapy machine. Post-operative radiotherapy was delivered by medial and lateral tangential fields daily, in addition to supraclavicular field with 200 cGy per fraction to a total dose of 5000 cGy in 25 fractions. The detectors of rainbow dosimeter were employed for these measurements.

The dose at the contralateral breast measured by a rainbow dosimeter for tangential fields was between 5.34–6.40% whereas for supraclavicular field it is 1.2–1.75% of the dose. The contribution due to the medial tangential field is almost twice as that due to lateral tangential field so that maximum dose which contributes contralateral breast dose is due to medial tangential field. The goal of this investigation was to quantify the radiation dose to the contralateral breast after radiotherapy for primary breast cancer. Rainbow dosimetry is easy, accurate and convenient method to measure the contralateral breast dose.

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1. Introduction

Breast cancer is the most common cancer among women, worldwide. It is probably the most feared cancer in women because of its psychological impacts. It affects the perception of sexuality and self image to a degree far greater than any other cancer. It is becoming number one killer in females. Therefore it has become an increasingly important subject of research all over the world. Globally, every 3 minutes a woman is diagnosed with breast cancer, amounting to one million cases annually. According to World Cancer Report, the incidence could go up by 50% to 1.5 million by 2020 (Mahavir & Babita, 2013). In India and other developing countries, breast carcinoma ranks second only to carcinoma of cervix among women, however the incidence of breast cancer is on the rise and may become the number one cancer in females in the near future. It is estimated that at present approximately 80,000 cases occur annually in India and by 2030 the number of new cases of breast cases will approximately be 200,000 per year (Datta, Choudhuri, Guha, & Biswas, 2012; Gupta, Sharma, & Verma, 2002)

Breast cancer is most curable when detected at its earlier stages. Radiotherapy plays an essential role in the management of breast cancer and many studies have shown better survival of patients after mastectomy followed by radiotherapy (Keyvan, Nazli, Shadi, & Alireza, 2013). Although radiation is a cancer healer, but it also carcinogenic, therefore it has been described as a "two edged sword". Women with breast cancer have three-to four-fold increased risk of developing a new primary cancer in the contralateral breast, as compared with the risk of a first primary breast cancer among other women (Adami, Bergstrom, & Hansen, 1985; Harvey & Brinton, 1985). In general, Radiotherapy for breast cancer after mastectomy and breast-conserving surgery include chest wall and for patients with regional lymph node involvement, the supraclavicular region should be regularly irradiated (Fisher et al., 2002). For patients receiving irradiation to both the chest wall and supraclavicular area, the irradiation field area is generally divided into two groups by the baseline of the lower edge of the subclavian head: one pair of tangential beams to cover the chest wall and interior beam to cover the upper supraclavicular area as shown in Fig. 1. During external beam therapy of malignant breast, the contralateral breast receives radiation due to leakage from collimator and scatter from primary beam. Breast is highly radiosensitive tissue for radiation induced second malignancy and is of more concern for female younger than 45 years of age receiving radiotherapy for breast malignancy. Boice, Land, Shore, Norman, and Tokunaga (1979) have reported that incidence of dose received by the contralateral breast and the latent period is over 10 years. Several investigators (Frass, Roberson, & Lichter, 1985; Kelly, Wang, Chu, & Hartselle, 1996; Muller & Kalokhe, 1990) have measured the contralateral breast dose on Anderson female phantom/Rando phantom observed that the scatter dose to contralateral breast during medial tangential and supraclavicular field is quite high and some times of the order of 500 cGy for 5000 cGy primary breast dose. The quantification of the contralateral breast especially during treatment of diseased breast by external beam is very important, as the scatter contribution will be more.

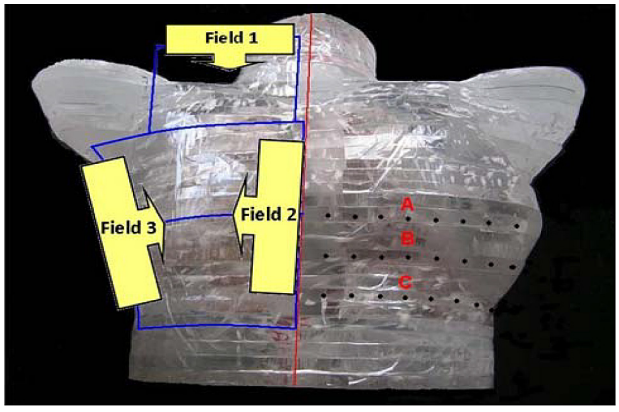

Fig. 1 – Anterior view of treatment fields of the patient positions.

In the present study, measurement of contralateral breast dose is done by using rainbow dosimeter with solid state detectors because of small size, high sensitive ability to record very small doses and energy independent response. The detectors of rainbow dosimeter were employed for the measurement of radiation doses to contralateral breast. The dosimeter has applications for relatively low doses and dose-rate independent up to 10^{-8} Gy s^{-1}. The system is also independent of relative humidity and can be used over a broad temperature (0 to 5 °C). The integrated radiation effect that is used for the measurement is the shift in threshold voltage due to trapped charge in the multilayered device. This threshold voltage is evaluated in the measurement of the channel (drain) current as a function of gate voltage at a constant supply voltage to the device.

2. Materials and methods

In present study contralateral breast dose was measured in forty breast cancer patients undergoing external beam therapy by cobalt-60 teletherapy machine. In radiotherapy for breast cancer, the chest wall was treated with medial and lateral tangential fields daily. Total Dose of 5000 cGy is given in 25 fractions to the chest wall with a dose of 200 cGy per fraction. Patients are usually placed in the supine position on an angled breast board with one or both arms stretched above the head. The position of the patient is kept similar in treatment and simulation. The patient is placed on an angled breast board because the sternum slope and chest wall slope is modified. Tangential fields must cover the breast and edges of the field are shaped based on patients' anatomy. In addition to these tangential fields, a supraclavicular field is also given with radiation dose of 5000 cGy and fraction dose of 200 cGy in 25 fractions.

Three detectors were put on the surface of the skin of contralateral breast, one at the level of nipple and two other detectors were placed 3 cm away from the nipple on both sides along the middle line for each field as shown in Fig. 2.The most widely accepted technique for whole-breast irradiation is the tangential field technique, in which the entire breast and chest wall, with a small portion of lung, is included in the irradiated