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Patient Specific Imaging Protocol for Optimizing Dose to Contra Lateral Breast

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Abstract- Present study provides information about breast doses from Varian CBCT low dose thorax protocol and describes simple method to reduce dose to breast**.** Several researchers have reported the breast dose either measured on anthromorphicphantom or using monto-carlo simulation . Limitation of phantom based dosimetry is its fixed geometry and difficulty to study quality of images. In this study, we measured dose to contralateral breast with vendor supplied CBCT protocol and modified CBCT protocol. We also studied impact of alteration in acquisition parameter on dose to patient and quality of CBCT image.From measured doses it was concluded that breast dose depends upon selection of imaging protocol and frequency of imaging, we observed quality of CBCT images is useful with modified imaging protocol. However, undoubted advantages of imaging system should be counter balanced by careful consideration of imaging protocol especially for very intense imaging sequences.

Keyword-*CBCT,breast,phantom,imaging*

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I. INTRODUCTION

Breast conservation surgery followed by radiation therapy is being considered as preferred choice for early stage breast cancer management. With increase in screening program, more and more women, especially in younger age, are being diagnosed earlier and are treated with breast conserving therapy. Conventional external-beam radiation therapy treatment for breast cancer uses parallel opposed tangential fields to provide sufficient coverage of target breast tissue while delivering minimum dose to critical structures lungs and heart. But over the time, there has been a rapid increase in the utilization of advanced radiation delivery techniques such as intensity modulated radiotherapy (IMRT) and Volumetric modulated arc therapy VMAT for breast radiotherapy (1)

For setup verification in breast cancer patients, electronic portal image devices (EPID) are commonly used. EPID uses bony anatomy as a surrogate for the breast set up verification. Now days three dimensional image guided radiotherapy (IGRT) techniques are used for breast patient setup verification and it has shown some advantages over EPID based techniques. EPID registration underestimated the actual bony anatomy setup error in breast cancer patients by 20% to 50%. Using cone beam computed tomography (CBCT) decreased setup uncertainties significantly (2-3). It is also likely to permit a reduction in planning target volume margins and provide skin-line visualization and dosimetric evaluation of cardiac and lung volumes. But 3D IGRT delivers 30-50% extra dose to normal tissue as compare to EPID base verification techniques.

Radiation therapy is associated with increase in risk of secondary cancer developing in the contralateral (untreated) breast in breast cancer survivors. Probability of developing second cancer increases with increase in radiation dose to contralateral breas.[4] During course of radiotherapy contralateral breast is exposed to leakage radiation and scattered radiation. With use of 3D IGRT, imaging dose also contributes additional dose to contralateral dose. So it is very important to optimized imaging dose to contra lateral breast. To optimize dose one needs to select proper CBCT acquisition parameters and optimize number of CBCT images. In this study we measured contra lateral breast dose with vendor specified protocol and modified protocol. We also studied effect of modified acquisition parameters on quality of CBCT images.

II. Material and Method

Varian OBI

The kV CBCT beam used in this study was from Varian OBI (version 1.4) system integrated into a Clinac IX linear accelerator (Varian Medical Systems, PaloAlto, CA).The x-ray tube is equipped with a rotating W-Re target (G242). The tube potential can be set in range of 40 to 125 kV. The is center of the CBCT is at 100 cm from the x-ray source and the source-to-detector distance can be 140, 150, and 170 cm. The maximum x-ray field size at 100 cm is 50 x 50 cm^2. The OBI system has two working modes: full-fanbeam mode and half-fan beam mode. In the full-fan beam mode the detector is centered on the axis of rotation and is usedto visualize regions with a small diameter or small soft tissue organs, such as the prostate. The diameter of the field of view is 25 cm. In the half-fan mode, the detector is shifted in a direction perpendicular to the kilo voltage X-ray beam, increasing the scanned area, hence enlarging the diameter of the field of view from 25 cm to 45 cm. In both cases, a filter must be placed at the exit of the X-ray tube. OBI system is built with preconfigured CBCT acquisition protocol/template.These protocols are region base like head and neck,thorax or pelvis etc. Some of parameters of these protocols can be edited by user.

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OSL based eye lens dosimeter:

We used OSL based eye lens dosimeters to measure breast dose**.** The α-Al2O3:C optically stimulated luminescence (OSL) based eye lens dosimeter (Fig 1) contains two discs loaded in a cassette having two filter regions viz.: i) first region has 1.35 mm thick Teflon filter (~300 mg cm^{-2}) and ii) second region has 0.3 mm Cu & 0.8 mm Al filter on both sides of the dosimeter. The eye lens dosimeter is capable of measuring doses in the range 0.10 mSv-1Sv (10). The α-Al2O3:C OSL discs used in the above dosimeter have diameter 7 mm and thickness of 0.14 mm (25 mg/cm2) respectively and have been prepared by sandwiching the α-Al2O3:C powder of grain size (75 -100) µm; between two thin transparent plastic sheets.

For the present study, only those dosimeter discs were used which have spread in sensitivity ≤ ± 5%. After experimental irradiation, the OSL discs were read individually using well calibrated RISO TL/OSL system (TL/OSL-DA-15) which have a cluster of 42 blue light emitting diodes (λ = 470 ± 30 nm) for stimulation. A green long pass GG-420 filter minimizes the directly scattered blue light from reaching the photomultiplier tube (EMI 9235QA). The blue light stimulated signal was detected using a 7.5 mm thick x 35 mm diameter HOYA U-340 (λp~340 nm, FWHM~80nm) filter (6). The OSL was recorded at a power of 22.5 mW/cm^2 for 60 seconds. After subtraction of control counts from irradiated dosimeters, the dosereceived by the eye lens dosimeter was estimated. Further comprehensive details about eye lens dosimeter badge and associated details can be had from the publications of Kulkarni et al. and Kumar et al. (5-6).

Dose measurement

Three OSL dosimeters were placed on the contra lateral breast as shown in figure. One dosimeter was placed at center of breast and other two dosimeters were placed 5cm apart from centrally paced dosimeter.

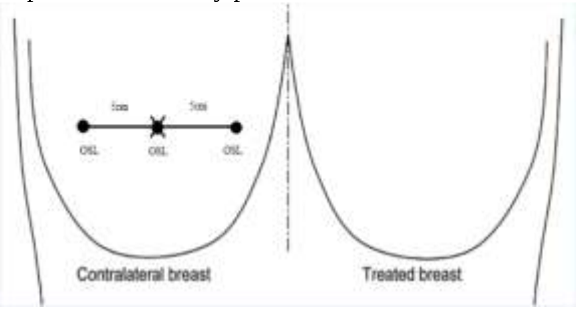

Figure 1: Dosimeter position

Vendor supplied low dose thorax imaging protocol was used for all measurements. CBCT acquisition parameter for low dose thorax protocol is defined in table2. All CBCT acquisitions were performed with fixed geometry for all measurements. CBCT images were acquired with half-fan cone with bow tie filtration, source-detector distance of 150 cm, 0.25 cm slice thickness, transversal field-of view (FOV) of 25 cm, and a scan length of 18 cm giving a longitudinal FOV of approximately 17.5 cm. Scans were performed with 360 degree rotation of gantry. To get a reasonable signal, dosimeters were irradiated in five consecutive scans for the CBCT imaging protocols. Average dose of three OSL dosimeters was reported.

For same patients CBCT images were also acquired using modified low dose thorax protocol. In modified Low dose thorax protocol tube current was reduced from 20mA to 10 mA. CBCT acquisition parameters are as shown in table 3 Dose to contra lateral breast was measured in same three positions as shown in figure 1.

	Low-Dose Thorax	**Modified Low Dose Thorax**
X-Ray Voltage (kVp)	110	110
X-Ray current (mA) Per projection	20	10
X-Ray Millisecond (ms) Per projection	20	20
Gantry Rotation Range (degree)	360	360
Number of projection	655	655
Exposure(mAs)	262	262
Fan Type	Half fan	Half fan
Default pixel size	384 x3 84	384x384
Slice Thickness(mm)	2.5	2.5
Reconstruction Filter	Standard	Standard
Ring Suppression Algoritham	Medium	Medium

Table 1.CBCT Parameters used for images acquisition

Quality of images

Effect of changing tube current on quality of images is evaluated by inspecting two set of images visually. We also quantified the change in the quality of images using fusion algorithm. Two sets of CBCT images were acquired for patients, one with vendor supplied low dose thorax protocol and one with modified low dose thorax protocol. We fused two sets of CBCT images with planning CT. We used automatic fusion software to fuse images and calculated patient positioning error. Results are shown in table2.

Results

The averaged absorbed dose with two CBCT protocols is shown in figure 3.The absorbed dose per fraction using the CBCT for standard low-dose thorax protocol was 9 ± 0.30 mSv; for the “Modified Low dose thorax” protocol it was 4.8 ± 0.21 mSv; it can be seen that the “Modified Low dose thorax” protocol results in a reduction of 51% in absorbed dose compared to the standard low-dose thorax protocol. It was also noticed that, by changing acquisition parameters quality of both scans were comparable as shown in fig .We also observed nearly same setup error using two scanning protocol. Maximum deviation observed was of 2mm. Accepting fusion result is subjective and it can vary from person to person. But we noticed that operators were able to use both set of images comfortably for quantification of patient setup errors.

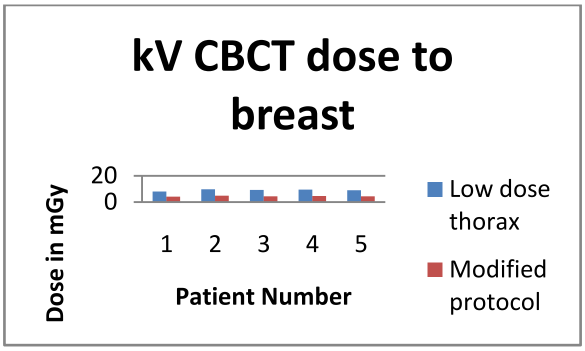

Figure2. Absorbed dose to contra lateral breast

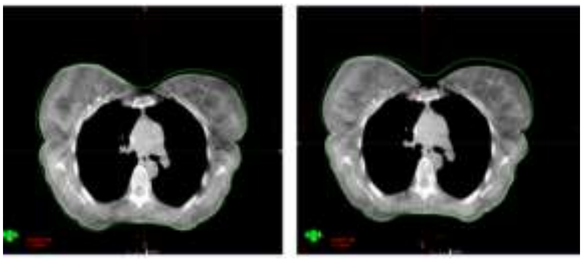

Figure 3.CBCT image with low dose thorax and modified low dose thorax protocol.

Patient Number	Low dose thorax protocol (cm)			Modified low dose thorax protocol (cm)		
	X	Y	Z	X	Y	Z
1	.4	.6	.8	.5	.8	.4
2	.5	.4	.5	.6	.4	.5
3	1	.5	.2	.7	.3	.4
4	.9	.2	.9	.5	.4	.3
5	.4	.7	.5	.8	.2	.9

Table 2. Set up variation along three direction using two protocols(X-medial lateral direction, Y –anterior posterior direction and Z-crano caudal direction)

DISCUSSION

This study provides information about breast doses from Varian CBCT low dose thorax protocol and describes simple method to reduce dose to breast**.** Several researchers have reported the breast dose either measured on anthromorphic phantom (7) or using monto-carlo simulation (8-9). Limitation of phantom based dosimetry is its fixed geometry and difficulty to study quality of images. In this study, we measured dose to contralateral breast with vendor supplied CBCT protocol and modified CBCT protocol. We also studied impact of alteration in acquisition parameter on dose to patient and quality of CBCT image. In literature different methods are suggested to reduce CBCT imaging dose (10-12).

Now days CBCT images are used for different purposes like to find patient set up error, tumor location and to alter treatment port. Depending upon the task for which CBCT images are used, requirement on quality of images varies. It was observed the application of imaging procedures and imaging frequency in the radio therapeutic management of cancers remains non personalized: a “one protocol- fits-all” practice is often implemented in the clinicworldwide. The CBCT imaging protocols provided by manufacturers are uniformly applied without considering individual differences of patients being scanned. As such, children and petite adults may be overexposed from the default site-specific CBCT protocols (e.g. high-quality head or low dose thorax or pelvis protocols) owing to reduced tissue attenuation. At the same time, larger patients with same protocol may result in underexposure with suboptimal image quality and, often resulting to unnecessary repetition of radiologic procedures. Malone et al (13)recently reported that a high rate of inappropriate or unnecessary examinations (from approximately 20%-77%) results in unnecessary radiation exposure and financial burden to patients, as well as additional workload for medical practitioners. Because radiation exposure should always operate under the principle of “as low as reasonably achievable,” more recently, the ‘Image Gently’ and ‘Image Wisely’ campaigns have been initiated to increase awareness of the opportunities to lower radiation doses in the imaging of children and adults respectively for radiological examinations. It is the time to incorporate personalized imaging protocols into kV cone beam CT. to address the ever-increasing radiation doses from current, uniformly applied imaging practices. By personalized kV CBCT imaging protocols, patients will benefit from first clinically justified and customized imaging procedures for improved image quality and second, cancer patients who may be more vulnerable to radiation carcinogenesis will be better protected from unnecessary radiation exposure.

CONCLUSION

From measured doses it can be concluded that breast dose depends upon selection of imaging protocol and frequency of imaging, we observed quality of CBCT images is useful with modified imaging protocol. However, undoubted advantages of imaging system should be counter balanced by careful consideration of imaging protocol especially for very intense imaging sequences.

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