Analyzing the Positional uncertainties in 3dcrt ca breast Patients with Free Breathing and Active Breath Coordinator Gating Immobilization Devices

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Abstract

Aim: The aim of this study is to rule out the difference in positional setup errors when using immobilization device such as thermoplastic mould for free breathing and vacloc with ABC gating in ca breast patient treating with 3DCRT technique.

Objective: The study is to compare the patient setup uncertainties using two different immobilization device, one with standard thermoplastic mould and other with vacuum cushion with active breath control gating in our clinical setup.

Methodology: fourteen patients with ca breast are taken for the study. seven patients are undergone immobilization using standard thermoplastic moulding and remaining seven patients undergone, vacuum cushion with active breath control DIBH (deep inspiration breath hold) gating. CT was taken and 3dcrt plan were done according to the standard protocol. Prior to the treatment CBCT was taken, matching was done in XVI with the reference images, to rule out any positional shifts. Positional Shifts on all 3 axes such x, y, z is noted with rotational shift. Comparison were done on systematic error (Σ), random error (σ), mean displacement vector (R), mean setup error (M).

Result: immobilization device used by vacloc with DIBH ABC gating shows very less shifts in all direction, especially longitudinal direction compared with mould one, which we are using routinely in our department.

***Keywords**: ABC, CBCT, xvi, DIBH gating, 3DCRT*

Introduction

Radiotherapy is one of the most effective mode of treatment for all types of carcinoma. There are different techniques in radiotherapy such as 3dcrt, forward planning, imrt, vmat, Tomotherapy etc, present today. Ca breast is a common cancer found in women all over the world with symptoms include lump or mass in the breast, nipple discharge or redness, changes in the skin such as puckering or dimpling, and swelling of part of the breast. Breast conservative therapy is the most common technique in radiotherapy for saving breast. It is done usually after lumpectomy, adding radiation after a surgery lowers the risk of cancer recurrence in the affected breast.

Many women go through radiation therapy for breast cancer, and roughly more than 60 percent of people with early-stage breast cancer will undergo adjuvant radiotherapy followed by surgery. It also helps in reduces the breast cancer death rate. The important and main step in radiotherapy is to immobilize the target, so that the beam can only target the carcinoma and spares the normal tissue. It is a very difficult process especially in thorax and abdomen region to retain the same position on every single day for the treatment, due to the involuntary motion it involves. The nature of breast, supraclavicular nodes, its region of avoidance contours etc. Different means of immobilization devices, are there especially for ca breast to reduce the positional errors. Thermoplastic mould is one of its kind and commonly used in all radiotherapy center for the radiation treatment, even there are breast board, wedges, etc can also be used. While using this types of immobilization devices the main concern is the errors caused by the involuntary movement such as breathing movement. To limit this types of errors gating's are coming in the picture. By the help of gating technique, we can arrest the breathing motion errors, one of its kind is active breath coordinator device. Respiratory gating is used when there is a need to reduce the anatomical movement in the thorax and abdomen due to breathing and cardiac motion.it is intended for breath hold during simulation and treatment delivery[1].The Active Breathing Coordinator (ABC) allows for temporary and reproducible immobilization of internal thoracic structures by monitoring the patient's breathing cycle and implementing a breath hold at a predefined lung volume level. Active Breathing Coordinator provides non-invasive, internal immobilization of anatomies affected by respiratory motion, such as the breast, lung, liver, pancreatic etc. This is achieved through comfortable, simple and efficient assisted breath-hold techniques. Linked to the digital accelerator through the Response™ gating interface. Respiratory-gated radiotherapy offers a significant potential in improving the irradiation of tumor sites affected by respiratory motion such as lung, breast, and liver tumors [2 ,12].

in this study we were evaluating the impact of controlled breathing using , Active breath coordinator gating with normal free breathing with thermoplastic mould in our radiotherapy setup.

Methodology

There are studies showing reduction in heart dose can be achieved for many left-sided breast and chest wall patients using deep inspiration breath-hold[4].There are studies done in various department in ca breast using different gating methods using infrared, markers or fiducial which are surgically inserted, real time tracking using kv xray beam etc. This study is conducted at Kasturba Hospital using ELEKTA HD versa XVI cbct. Ethical approval was granted by the Institutional Ethics Committee, Kasturba Medical College, Manipal. The study was also registered under CTRI. fourteen breast cancer patients who were planned to treat with 42.5 Gy in 16 fractions were chosen for this study. Age range from 41 to 67 yrs., out of this 8 patients are with T1N2aM0 stage.

Seven patients were immobilized using thermoplastic chest mould (klarity) with four clips and seven by using vacloc with active breath coordinator in deep inspiration breath hold under Standard Operating Procedure in moulding room. Selection for the ABC gating is completely biased. Before the gating, patients are well explained and trained for the procedure. Patients with previous history of lung, heart problem, etc are avoided from ABC gating.

Contours, prescription are done based on ICRU protocol[3]. Standard tangential 3dcrt beam planning was generated using 6 mv or 10 mv photon with wedge. Plans are evaluated by experienced radiation oncologist before sending for verification and treatment. Patients were imaged with CBCT on first consecutive three days and every third day during their course of treatment. CBCT was taken before each fraction. In all, 6 CBCT images were acquired for each patient for 3 weeks. A total of 84 images are obtained. Image registration was done first by automatic and then by manual adjustment by the same person for all the patients. Patients were positioned supine, with both arms raised above their head and immobilized by thermoplastic mould[5]. During the mould making process, three fiducial markers were placed on the patient's body with the support of laser for isocenter reference mark. CT was taken with slice thickness of 5 mm in Philips brilliance 16 big bore and pushed Monaco™ TPS V5.11.02 treatment planning system (TPS) for delineation of the targets and OAR. once plan was done, all plans were approved by a radiation oncologist and transferred from TPS to CBCT system for the treatment delivery along with the corresponding planning CT datasets which will be used as the reference image data sets. The planning CT-scan was imported into the XVI database via DICOM. XVI system consisted of kilo-voltage X-ray source arm and amorphous silicon flat panel imager, is together with Elekta HD versa® (Elekta Ltd, UK) linear accelerator was used as the IGRT system to acquire onboard CBCT images. Patient's 3D-CBCT images are acquired at isocenter after applying the shift from the origin, which we got from the treatment planning station. Rotational shifts such as pitch, yaw and roll are not considered in this study. If the rotational error is more than 3^{o}, patients are repositioned and images are taken once again

Images in cbct were acquired within one-minute time span, 360-degree rotation with the patient immobilized in the treatment position same like during CT acquisition. M20 collimator cassette was used on all patients giving a nominal irradiated scan length at the isocentre of approximately 26 cm and reconstruction diameter of approximately 40 cm. the acquisition parameters were 120 kV, (with clinical filter F1), maintaining the lower dose to the patient's skin but improving image quality. The image acquisition parameter of xvi is given in table 1 below. Commissioning and calibration of the CBCT isocentre to the linear accelerator isocentre was performed prior to this study according to recommended guidance AAPM TG 58[5].

Table 1: acquisition parameters of xvi CBCT

KV	**120**
MAS	140
Gantry rotation	Clockwise (3600 arc)
Collimator	M20
Filter	F1
Frame	660
Reconstruction filter	wiener
XVI software	Version 5.0.3
Nominal scan dose	3.8 mGy

Image registration was first done automatically by using Clip-box registration (CBR) method, the volume of interest is defined on the CT image in the form of a box drawn around the anatomy of interest[4]. The registration between image sets is limited only to the voxels within the clip box which contains the volume. It is a rigid registration process and does not include any margins during image matching. Once automatic matching was done next step was to do a manual matching to rule out the small mismatch correction in automatic clip box registration. In manual registration we use mouse to move the reference image with translational and rotations. Even though Manual matching is a time taking registration, it is superior than automatic one[4]. Out of automatic matching, the gray value (T + R) registration use grayscale intensity values of the voxels in the registration volume. The algorithm used here is correlation ratio procedure. The bone (T+R) mode of automatic registration use chamfer matching algorithm[9], to calculate the same as bone densities. Since the algorithm is not very sensitive to image noise, this registration can have done very quickly.

The deviation between the actual and intended position in a patient treatment is called the setup errors. Mainly two types of setup errors are present while treating a patient in external beam radiotherapy, such as systematic and random error. Systematic part of an error is one which occur systematically (same direction and magnitude) throughout the delivery[7]. This types of errors may be introduced into the treatment during immobilization preparation, planning, while transferring the data, during delivery etc.so Systematic errors are sometimes called as treatment preparation errors, It can be calculated by standard deviation of the mean error of individual of that population and is represented by the symbol $\sum$. whereas random error which is represented by σ, is one which direction and magnitude of error will vary from each fraction during the treatment. This type error is usually occurring during treatment delivery phase may be due to patient's setup, tumor position, intra-fraction movement and sometimes called as daily execution errors. Which can be calculated by the root mean square of the standard deviation of each patient.

It is easy to reduce the random error to some extent than systematic error[5]. The mean setup error (M) is the average of the setup error in each direction. Whereas mean displacement vector which quantifies the distance and direction of patient setup errors can be calculated using

$$M = \sqrt{(AP)^2+(RL)^2+(SI)^2}$$

Where RL, SI, AP is deviation in three axis of patients respectively[8].

Results and Discussion

It is shown in study done by Mageras GS, Yorke E that Gated treatment offers reduced respiratory motion with less patient effort than DIBH[10].However in this study gating was done in DIBH mode where normal OARS can be saved at the same extend[11]. The result of present study is expressed in tables and chart given below. The mean and standard deviations were calculated. The mean value expressed the systematic error and the standard deviation describes the random error of individuals[7]. The residual population systematic setup errors data are shown in fig 2. The major shifts are noted in longitudinal direction (SI), the mean of superior inferior (SI), in mould is 4 mm in mould and 1 mm in ABC gating. The random error in RL, SI, AP is 1.6, 4.4, 1.4 mm in ABC gating, where as in mould it is 1.7, 6.1, 2.4 mm respectively. The patient's translational errors of both mould and gating are shown below in fig 1.

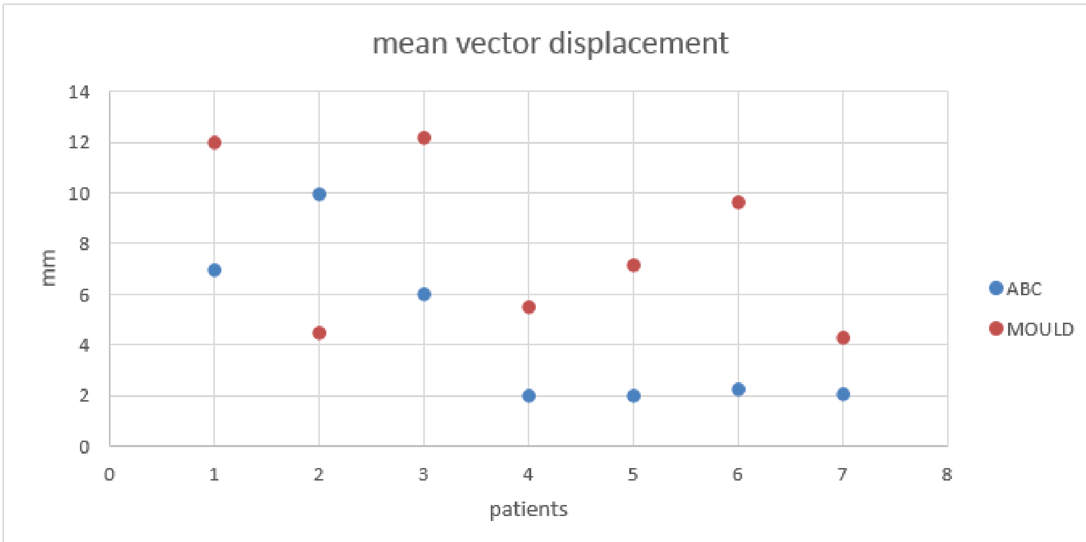

Fig 1: scatter plot distribution of mean vector displacement for each patient in ABC gating and mould immobilization

The vector displacement for mould varies from 3.6 mm to 12 mm, whereas in ABC gating it is from 2.1 to 10 mm. The sample size chosen for this study is very less, more number of samples are needed to know the exact shift difference in all axes. The random error noted for ABC gating is 1.6, 4.5,1.4 mm and 2.0, 6.0, 2.0 mm for mould in RL, SI, AP respectively. The systematic errors of population are given below in fig 2.

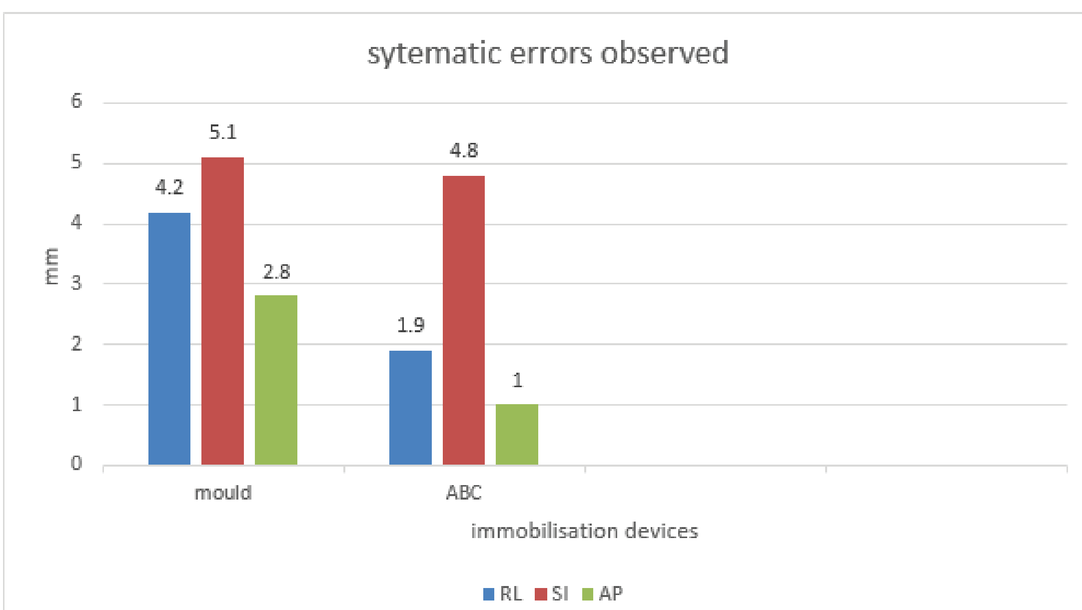

Fig 2: population Systematic (Σ) errors calculated

(X (RL): Medio lateral, Y (SI): Craniocaudal, Z (AP): Anteroposterior) all reading are in mm)

Conclusion

From this study, in our clinic it is found that by using active breath control gating, we can reduce the systematic and random error to a great extended compared with the normal free breathing mould immobilization. One drawback noted in ABC gating is that selection of patient which is a biased one, a complete cooperation of patient is a must for doing all this procedure. Second it is a tedious process compared with the mould technique. A proper training of patient is needed, prior to immobilization simulation and treatment

Conflict of Interest: No potential conflict of interest relevant to this article

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