I. Introduction
Lung tumors have an intrinsic motion due to breathing. Conformal therapy of all types; 3DCRT, IMRT and SRS, requires accurate localization of target. At our institution, we use 4DCT scanning along with free-breathing scan for 3D CRT planning. In this poster, we present the technique used in obtaining the necessary information from 4DCT and case comparison between free-breathing CT and 4DCT, to show advantage of the technique.

II. Method and material
Philips Big Bore CT scanner was used with the respiratory belt provided. The patient was asked to lay down on the CT table and the breathing of the patient is observed. The respiratory belt is then positioned according to the observed breathing, on abdomen or chest. Fig 1a, shows the respiratory belt placed on the patient. The breathing cycle is then registered by the software. Fig 1b. We choose to do a 10-phase study, such that the CT scans are obtained over 10 phases of one breathing cycle.

III. Tumor motion, MIP, ITV and expansion
Tumor motion: After obtaining the 10-phase scan, the tumor motion is analyzed in all three dimensions; Superior/Inferior, lateral and AP/PA. The lateral and AP/PA motion of most lung tumors was minimal, less than 1mm, regardless of the location. However, the superior motion of the tumor is greatly affected by its location, with the largest motion exhibited for Superior/Inferior, lateral and AP/PA. The lateral and AP/PA motion of most lung tumors was minimal, less than 1mm, regardless of the location. However, the superior motion of the tumor is greatly affected by its location, with the largest motion exhibited for Superior/Inferior, lateral and AP/PA.

MIP: On the CT console, a maximum intensity projection (MIP) dataset is created. MIP represents the location of the tumor in each slice for all phases. ITV: From the MIP dataset, the observed tumor is delineated. This is the Internal Target Volume, ITV, which represents the location of the GTV in all breathing phases. Figure 2 illustrates this.

Expansion 4DCT: The expansion margins used to create the ITV from the MIP dataset are as follows: Superior/Inferior: 1.5 cm All around: 1.0 cm These margins are reduced from the margins that were used at our institution before 4DCT. Previously, the expansion margins were: Superior/Inferior: 2.5 cm All around: 2.0 cm

IV. Planning and dose conformity
To analyze the impact of 4DCT, and the new expansion margins on the treatment planning, we calculated two plans for two cases. For each case, one plan was done using regular CT scan and the conventional PTX expansion, while the other plan was done using 4DCT imaging and the modified expansion. PTV coverage in both plans satisfied the following minimum criteria: At least 95% of PTV receives at least 95% of dose, and no more than 107% hot spot was acceptable. Both plans consisted of five beams with forward planning technique, i.e., each beam could contain multiple MLC segments or control points. Figure 3 shows an isodose comparison, of one of the cases, between conventional imaging and expansion, Fig. 3a, and 4DCT imaging and modified expansion, Fig. 3b. It is obvious that better conformity is achieved with the 4DCT volume.

V. Change in PTV volume
The use of 4DCT imaging leads to an increase in the GTV volume due to the fact that the ITV encompasses all the locations of tumor motion. The increase in volume is as much as 34%. However, because the actual target motion is known and the expansion margins of PTV are reduced, the PTV volume itself is reduced by more than a half, as in table 1 below.

VI. Involved lung volume, ILV
To find the impact on the lung dose, the volume of the healthy ipsilateral lung tissue included in the PTV was defined as the “involved-lung” volume, ILV. The uninvolved lung volume was thus, the volume of the ipsilateral lung minus the involved volume. Table 1, below, indicates that about 8% of the lung volume has been “spared” from being included within the PTV volume. This will reflect in lower dose to the lung and an improved DVH.

VII. Dose to the lung
The dose to the lung was scored at four volume points; the mean lung dose (MLD), the dose to the 20% volume, dose to the 30% volume and dose to the 40% volume. There is a general reduction of about 20% in the dose delivered to the lung.

VIII. Dose to other structures
Due to the reduced PTV volume, and the better conformity of the isodose, dose to the heart and spinal was also reduced, the DVH below shows the effect on the heart and the spinal cord.

CONCLUSIONS
The use of 4DCT imaging technique enables the delineation of the entire path of the tumor. This increases the accuracy of radiation delivery and reduces the required expansion for the PTV. A direct result of this reduction is lowering the dose received by lung tissue by about 20%.

REFERENCES

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