Purpose: To assess the accuracy with which stereotactic body radiotherapy (SBRT) is delivered via cone-beam CT (CBCT)-based image-guided delivery methods.

Methods and Materials: SBRT treatment plans from ten patients with primary lung tumor were retrospectively reviewed. In this retrospective study on ten lung cancer SBRT patients, ten free-breathing planning CT (pCT) scans were acquired along with 38 CBCT scans. Virtual simulation was performed using pCT scans and a CBCT image was acquired on each fraction of treatment to ensure set up accuracy. The CBCT information acquired just prior to the treatment provides the latest patient anatomical information and provides a way to independently verify the dose delivered to any organ of interest. Contours of the gross tumor volume (GTV), planning tumor volume (PTV) and relevant organs at risk (OAR) were drawn by the physician on the pCT and on each of the CBCT images. These contours were transferred from each of the CBCT images to the pCT image, after performing rigid-registration between the image pair. Treatment plan dose, delivered dose and dose volume histograms (DVH) were calculated in the pCT image from both the original contours and the additional set of contours derived from CBCT images which were then compared. The ratio of mean PTV delivered dose to the mean PTV planned dose was compared with the ratio of intersection of volume of PTV pair to union of the planned and delivered PTV volumes. A motion phantom study was performed to deduce the error in estimation of tumor volume in pCT and CBCT imaging systems.

Results: Reduction of tumor volume with treatment was insignificant within 2 weeks of SBRT. When averaged across patients over all fractions, the mean delivered dose to GTV and PTV had deviated from the planned dose by -1.1% and -2.4%, respectively. In only 1 of 38 fractions delivered to 10 patients, there was a substantial reduction in the mean dose delivered to GTV and PTV by 9.3% and 16.8%, respectively. While the maximum delivered-doses did not change significantly (<0.1%), the minimum delivered-doses to GTV and PTV deviated by -4.3±4.6% and -19.4±15.2%, respectively, when averaged across patients over all fractions. The substantial reduction in the minimum delivered dose to GTV and PTV compared to the minimum doses in the treatment plan is possibly attributable to breathing motion and tumor deformation. The mean and maximum doses to spinal cord and esophagus showed a negligible increase and were within the tolerance limits mentioned in RTOG protocol. A strong correlation coefficient of 0.75 exists between the ratio of delivered dose to the planned dose to PTV with ratio of volume of intersection of planned and delivered PTV volumes. Motion phantom study revealed errors of 6.9% and 5.1% in the estimated lesion volumes in pCT and the CBCT images, respectively.

Educational Objectives:
1. Understand the methodology of dose verification via online imaging methods.
2. Understand the differences between pCT and CBCT and their inherent deficiencies in estimation of tumor volume.