Purpose or Objective: The purpose of this study was to evaluate the clinical accuracy of the Synchrony Respiratory Tracking System (SRTS) of the CyberKnife (CK).

Material and Methods: We analyzed 65 patients with lung lesion who had been treated with the SRTS from August 2012 to August 2015. Respiratory motion data were obtained from cine magnetic resonanc (MR) images. MR scans were performed with a 1.5 Tesla whole-body clinical MR scanner, and the cine MR images of sagittal plane were obtained. We collected respiratory motion data of each patient from the cine MR images using in-house software. The dynamic motion phantom (DMP) was used to reproduce the motion of both the tumor and the surface of the patient’s abdomen. We used a 20 mm diameter plastic ball as the target. A gold marker was placed at the center of the ball. Treatment plans were created based on static CT scans and standard CK treatment parameters. Each plan utilized ten beams with several different source positions. All of the beams in each plan were aimed at the center of the ball target, and were set to 200 MU for 15 seconds of data acquisition. The CK was subsequently operated with the SRTS, with a CCD camera mounted on the head of the linac. The central axis of the CCD camera was matched to the central axis of the linac beam using a custom-built jig. The recording by CCD camera was performed during the tracking of the ball target by the linac. The tracking error was defined as the distance from the center of the images to the center of the ball in the images recorded by CCD camera. The tracking error was measured at 30 Hz using in-house software. The probability in excess of 95% (Ep95) for each direction was estimated. The SRTS accuracy was defined as the median value of Ep95 for ten beams (Ep95med)

Results: The mean value and standard deviation of Ep95med was 2.5 ± 0.9mm. The Spearman’s correlation coefficient determined by the rank test indicated that the range of motion of the tumor was significantly related to Ep95med (P<0.01).

Conclusion: The accuracy of SRTS was considered to be clinically acceptable. However, suitable margin to the clinical target according to the range of motion of the tumor seems to be necessary for the safe treatment to each patient.

EP-1745
Radiotherapy in breast cancer with voluntary deep-inspiration breath-hold using BrainLab Exactract
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Purpose or Objective: Adjuvant radiotherapy in left-sided breast cancer with voluntary deep-inspiration breath-hold technique (vDBIH) may reduce the irradiation dose to the heart. The aim of this study is to estimate the heart, lung and PTV dosimetric constraints and the reproducibility of vDBIH radiotherapy using BrainLab Exactract monitoring system.

Material and Methods: 10 women with left breast cancer who had undergone breast-conserving surgery and who required adjuvant radiotherapy to the whole breast, were enrolled and were shortly trained before simulation CT-scan to hold their breath. The first scan was acquired in free-breathing (FB_CT) and the second one in vDBIH (vDBIH_CT). Target and organ-at-risk (OAR) volumes were delineated in both CT scans and for both of them computerized treatment planning was performed using two tangential fields technique. We compared the dose distribution for the heart, left anterior descending coronary artery (LAD), ipsilateral lung and planning target volume (PTV) using standard defined parameters: mean dose and maximal dose applied to the LAD; percentage of the heart volume receiving at least 5 Gy (V5Gy) and 10 Gy (V10Gy); percentage of the ipsilateral lung volume receiving at least 20 Gy (V20Gy); and the volume of the PTV receiving 95% of the prescribed dose (V95%). The online monitoring during EPI acquisition and treatment were made by BrainLab Exactract system. Daily real time electronic portal imaging (EPI), in CINE modality (captured during the beam delivery) were performed in order to check the reproducibility of the technique. Wilcoxon test has been used to compare dosimetric heart, lung and PTV parameters between FB_CT and vDBIH_CT treatment plans. The mean displacement, detected with the portal images, was calculated for each treatment beam and for each patient.

Results: A significant reduction in heart V5 and LAD Dmax (2.71 vs 0.99 Gy p=0.02 and 16.56 vs 6.90 Gy p=0.012 respectively) parameters was recorded for vDBIH_CT treatment plans (see Table 1 for complete results). There were no significant differences between vDBIH and FB treatments in lung dosimetric parameters and target volume coverage. 1694 portal images were evaluated. During treatment, the mean displacements observed in the longitudinal, vertical and lateral direction were 0.132 mm (SD=0.011), 0.013 mm (SD=0.137), 0.116 mm (SD=0.010).

Conclusion: vDBIH technique reduces cardiac irradiation compared with conventional free-breathing treatments, without jeopardizing the proper coverage of the target. vDBIH for left-side whole breast irradiation can be accurately implemented using BrainLab Exactract system with high and accurate reproducibility (mean shift < 0.15 mm).

EP-1746
Stereo/monoscopic motion tracking of the prostate using room-mounted x-ray image guidance
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Purpose or Objective: Intrafraction internal motion of the prostate currently limits the accuracy of external beam radiotherapy, requiring expanded ITV boundaries and introducing geometric uncertainty. Techniques to monitor prostate motion at the millimeter scale are thus needed. Room-mounted dual x-ray systems can provide stereoscopic localization of the prostate via implanted fiducial markers, however the treatment head frequently blocks one of the x-ray tubes as the gantry rotates. We implemented a monoscopic 3D localization algorithm, allowing localization even when one of the x-ray tubes is obstructed. We show that this technique allows accurate localization throughout the treatment fraction, improving the tracking capabilities of room-mounted x-ray systems.

Material and Methods: A gold fiducial marker was placed in the prostate of an anthropomorphic phantom, and initially aligned to isocentre. The linac couch was used as a reference. Room-mounted x-ray systems.

Conclusion: vDBIH technique reduces cardiac irradiation compared with conventional free-breathing treatments, without jeopardizing the proper coverage of the target. vDBIH for left-side whole breast irradiation can be accurately implemented using BrainLab Exactract system with high and accurate reproducibility (mean shift < 0.15 mm).

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0.63 mAs) were acquired at 1 Hz. For stereoscopic localization, the intersection of the ray lines connecting the detected image locations with the corresponding sources was found, whereas monoscopic localization first computed a prostate position probability density function (PDF) based on previously published motion covariances, and then finds the maximum likelihood position along the ray line passing through this PDF. Stereoscopic and monoscopic localization results were compared to the ground truth provided by the linac log file.

Results: Both stereo- and monoscopic localization produced sub-mm accuracy (Figure 1). Monoscopic localization was nearly as accurate as stereoscopic localization, despite only directly resolving two dimensions. The left-right dimension tracked slightly less well with monoscopic localization as this dimension is less correlated with the other two axes, and thus harder to predict using the monoscopic algorithm.

Conclusion: The ability to use room-mounted x-ray systems to achieve sub-mm accuracy with either monoscopic or stereoscopic localization creates new opportunities for intrafraction tracking. Stereoscopic tracking can be used when both x-ray tubes are unobstructed, to produce the most accurate localization, and bridged by monoscopic tracking during obstructions. The knowledge of prostate position during treatment can potentially be used to gate treatment, or be fed back into dynamic MLC updates in order to produce more conformal dose delivery.

EP-1747
Assessment of PTV margins accounting for prostate intrafraction motion in SBRT with online IGRT
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Purpose or Objective: There is little consensus on the magnitude of PTV margins for IGRT of the prostate cancer when a hypofractionation scheme is applied and daily correction is required, rather than averaging over many fractions. The aim of this work was to assess PTV margins suitable for SBRT of prostate cancer uncertainties after daily online correction. Moreover, intra-fraction prostate motion is analyzed with the aim to identify its main causes (bladder filling, rectum distension, elapsed treatment time).

Material and Methods: Between 2013 and 2014, 43 patients with low or intermediate risk prostate cancer were treated with 7-fraction SBRT in supine position, with implanted fiducial markers (FM), empty rectum and full bladder. To reduce organ motion, patients were medicated with butylscopolamine and rectum gas was removed before the treatment. At each session pre-treatment kV/kV imaging was acquired to align the patient by matching the FM’s, while additional CBCT imaging was performed after treatment delivery to assess the intra-fraction motion. The van Herk’s formula was applied to calculate the PTV margins of prostate/seminal vescicles. To investigate the causes of organ motion, the bladder volume and the rectum wall distension were estimated from each CBCT with respect to the simulation CT images. Correlation between these anatomical factors and intrafraction PTV motion was assessed for each axis, as well as for the composite shift of the prostate volume. The treatment time elapsed from pre-treatment kV/kV to post-treatment CBCT imaging was also included in the statistical analysis.

Results: 301 pre-treatment kV/kV images and 301 post-treatment CBCTs were analyzed. After daily IGRT correction, margins accounting for residual uncertainties are estimated 3 mm for AP, 3 mm for Longitudinal axis and 2 mm for Lateral axis. A systematic increase of bladder filling with respect to simulation images was observed; however, these changes did not influence the prostate displacement (p = 0.55). Similarly, variations of the prostate position occurred independently from changes of the rectal distension (p = 0.32). A trend between internal prostate motion in the AP direction and elapsed treatment time was observed (p = 0.057). Finally, a significant correlation was observed between the intrafraction composite shift of the prostate volume and the elapsed treatment time (p = 0.036).

Conclusion: Our data suggest a good control of intrafraction motion with butylscopolamine medication and by careful emptying of the rectum before treatment. The prostate intrafraction motion is shown to be dependent on elapsed treatment time. In conclusion, in image-guided SBRT with online correction, PTV margins can be kept in the range of 3 mm provided that the elapsed treatment time is kept as low as possible.

EP-1748
An experimental comparison of advanced respiratory motion management techniques
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Purpose or Objective: Respiratory tumor motion enlarges the intra-fractional tumor position uncertainty. These uncertainties result in increased treatment volumes (PTV) and hence higher radiation dose to organs at risk (OAR). Also interplay effects between the moving target and dynamic treatment delivery have to be considered. Motion-management techniques (MMT) aim to reduce or deal with this intra-fractional respiratory tumor motion in the following ways: The internal target volume (ITV) concept with a PTV enclosing the whole tumor motion, the mid-ventilation (MidV) principle with probabilistic tumor margins, respiratory gating of the irradiation beam and treatment couch tracking with real-time compensation of the internal tumor motion. Dosimetric performances of these four techniques were investigated with film measurements in a sophisticated lung phantom.

Material and Methods: The anthropomorphic, deformable and dynamic lung phantom LuCa (CSEM and PSI) was operated with 5 different respiration patterns with 10 to 20 mm internal tumor motion amplitude. 4DCT scans were taken and individual SBRT treatment plans were prepared, adapting the PTV according to the four MMT (ITV, MidV, gating, tracking) and five respiration patterns. A dose of 8x6 Gy was prescribed to the 65%-isodose line enclosing the PTV using VMAT stereotactic treatment planning. The phantom was irradiated with all individual treatment plans using the corresponding respiration pattern and MMT, together with static measurements. The internal tumor motion was...