delivered to the heart and the volume of heart receiving the dose of 20 Gy or more were evaluated. Volume of the territory of the coronary arteries receiving the dose of 20 Gy or more was also assessed. All 10 patients were treated with the DIBH technique.

Results: DIBH compared to FB reduced the mean dose delivered to the heart (average 4.4 Gy vs. 2.1 Gy). The heart volume receiving the dose of 20 Gy or more was reduced almost to zero (average 0.1% vs 6%). DIBH allowed to diminish to zero the volume of coronary arteries receiving 20 Gy or more (average of 0% vs. 16.9%). The early treatment tolerance was good - no toxicity higher than Grade 1 skin toxicity according to RTOG Acute Radiation Morbidity Scoring Criteria was observed.

Conclusion: DIBH technique reduces the dose delivered to the heart in comparison to FB, thus it may reduce the late cardiotoxicity of radiotherapy. In each patient with the left breast cancer qualified to postoperative radiotherapy, the DIBH technique should be taken into consideration.

EP-1768
The impact of interplay effect in SBRT lung treatments for 6MV and 6MV-FFF beams using EBT3 film.
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Purpose or Objective: In hypofractionated stereotactic body radiotherapy (SBRT) for lung tumors, the interplay effect between tumor respiratory motion and multileaf collimator (MLC) motion can play an important role in dynamic plans. This study was designed to investigate the interplay effect for Rapidarc (RA) SBRT lung treatments, using GafChromatic EBT3 film and a respiratory motion phantom.

Material and Methods: A heterogeneous programmable respiratory motion phantom (Quasar, Modus Medical Devices Inc.), with a “tumor” (30 mm diameter) inside a cylindrical “lung” insert, was used to simulate a breathing motion in the superior/inferior direction. Two amplitudes (10 mm, 20 mm) and two breath rates (BRs) (period: 6 s, 4 s) were investigated. RA plans were created, based on the 4D CT scans of the phantom, one for each amplitude and beam quality investigated a) 6MV (600 MU/min) and b) 6MV-flattening filter free (FFF) (1400 MU/min). All plans were optimized to keep the MLC modulation about 200 MU/Gy. The internal target volume (ITV) was prescribed a fractionation dose of 22.5 Gy, where the planning target volume (5 mm margin to ITV) was covered by 67%. Each plan consisted of four half arcs, each measured individually. Measurements were carried out both in static condition and with motion for the two BRs. GafChromatic EBT3 film were placed centrally in the tumor, and the measurements were compared with calculated dose distributions where gamma analysis per field was evaluated (Verisoft v.4.0, PTW-Freiburg).

Results: All static measurements were in good agreement with the calculated dose, with a mean local gamma (LG) passing rate (3%/2 mm) above 96.8% (±0.9) for all fields. With 10 mm motion, the mean LG passing rate (3%/2 mm) for all fields in one plan was, with period 6 s: 88.4% (±2.4) for 6MV and 82% (±3.5) for 6MV-FFF, and with period 4 s: 78% (±12.6) for 6MV and 73.9% (±7.7) for 6MV-FFF. Worst case observed was with 20 mm motion, period 4 s and 6MV-FFF, with a mean LG passing rate (3%/2 mm) of 50.7% (±15.2). Only the 6MV plan with amplitude 10 mm and period 6 s passed a typical clinical acceptance criterion of 90% using 3%/3 mm LG passing rate.

Conclusion: The impact of interplay effect was highest for the largest motion amplitude (20 mm), fastest BR (4 s) and for the shortest delivery time (6MV-FFF beam). Although the results illustrate LG per field, the motion blurring may become dosimetrically significant when the fields are summarized, particularly for motions above 10 mm.

EP-1769
Evaluation of the intra-fraction patient movement for SBRT treatments in our Institution
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Purpose or Objective: The purpose is to evaluate the intra-fraction patient movement for SBRT treatments, obtaining a reference level in function of the pathology, starting point for future improvements. The parameters considered to be improved are the settings of these treatments: positioning, immobilization devices and maybe patient training.

Material and Methods: Data from 233 SBRT fractions (from 05/2013 to 09/2015) of 105 patients (SBRT different treatments) were studied. All patients have internal fiducial markers, and were treated with two Varian (cinac 2100C and 2100CD) linear accelerators both with Portal Vision A5500 - IAS3, the treatment planning system (TPS) was Philips Pinnacle v9.8, and the Record and Verify (R&V) was Mosaic (Elekta). The treatment plan was mainly 3DRT.

The treatment procedure for each fraction was:
Before each treatment session a new CT was made. All ROIs and fiducials were contoured in it. The displacements from external CT marks to isocenter were updated according to this
The patient was positioned on the couch with all the immobilization devices needed, and initially aligned with the lasers on the CT marks. Then it was moved to the isocenter according to the updated physics displacements.
Two Portal Images (orthogonal, 0°-90°) were done until their position corresponded to the one of the treatment plan. Fiducials were used to check the position against the portal vision. When the correct position was found, the first treatment field is irradiated.
For each treatment field, a Portal Image was made. It was checked with the corresponding RDR, repositioning the patient if necessary. Finally the field was irradiated. If the movement detected was greater than a half of the PTV margin, the 0° and 90° images were performed once again.
The treatment positions (couch coordinates) for each field were obtained from the R&V. The cases were classified according to two main categories:
Reposition in low % number of fractions: No action required by now.
Reposition in high % number of fractions: The immobilization devices and positioning of the patient should be checked improved.

Results: Position had to be corrected intra-fraction due to the PV in images in 36 of the 233 fractions (15.4%).
45 beams needed patient reposition, that means in average 1.25 repositions for each patient that needed to be repositioned.
These patients were treated with 245 beams (18.4% of the treatment beams needed reposition).
In Average, the movement magnitude (field to field) was 8 mm (4 movements greater than 3 cm), and the total session time was increased in 7’59’’, due to the reposition process.

Conclusion: The three most frequent tumor localizations were: lung, abdominal and cranial. With the collected data, patient setup must be improved in abdominal pathology.

<table>
<thead>
<tr>
<th>Localization</th>
<th>Sessions with fields repositioned</th>
<th>Total fractions</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung</td>
<td>20</td>
<td>124</td>
<td>16.13%</td>
</tr>
<tr>
<td>Abdominal</td>
<td>7</td>
<td>33</td>
<td>22.58%</td>
</tr>
<tr>
<td>Cranial</td>
<td>3</td>
<td>21</td>
<td>14.29%</td>
</tr>
</tbody>
</table>

There were other pathologies with low number of cases (Spinal cord, rectum...), so the study may not be yet representative.
This process implies an increase in the treatment time, but this is necessary for a SBRT efficiency treatment.

**EP-1770**

Predictive modeling of respiratory lung motion using single-phase CT and finite-element analysis

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**Purpose or Objective:** Information regarding lung motion can be highly valuable in modern radiotherapy. During recent years, 4DCT has been used to obtain such required information. This technology is, however, not available to all centres. It is, therefore, desirable to have a predictive model to aid the planning and delivery processes, although this has proven to be a challenging task given the complexities involved. The aim of this work is to develop a biomechanical finite-element model (FEM) of respiratory lung motion that only requires a CT dataset from the end-inhalation phase of the breathing cycle as input.

**Material and Methods:** A radiology specialist identified 10-18 uniformly-distributed landmarks per lung on each of the end-inhalation and end-exhalation 4DCT datasets for 13 lungs. After segmentation and surface preparation, the first 7 lungs (3 left and 4 right) were used to tune the FEM in the Abaqus FEA software environment. A hyperelastic model with reported parameters was used. Varying magnitudes of pressure were applied to 9 different segments of lung surface. These magnitudes were adjusted until the mean of the squares of the 3D distances between the predicted and actual landmark positions in the end-exhalation CT dataset became < 1 mm. Our tuned FEM was hence obtained. This model was then applied to the study 4DCT datasets comprising 6 lungs (3 left and 3 right). The 3D error vectors between the corresponding landmarks in the end-exhalation phase were calculated and analysed.

**Results:** Among all landmarks in the 6 lungs in the study set, the mean length of the 3D error vectors was < 2 mm, while the minimum and maximum lengths were 0.1 mm and 7.1 mm, respectively.

**Conclusion:** Overall, the tuned model shows reasonable accuracy in predicting the end-exhalation position of the landmarks in the lungs, using the input anatomy of only a single end-inhalation phase. These promising results encourage further development and evaluation of the model as well as its tuning over a larger number of patients.

**EP-1771**

Biological consequences of dynamic dose interplay in VMAT SBRT lung treatments

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**Purpose or Objective:** A dynamic dose delivery for stereotactic body radiotherapy (SBRT) of the lung in free breathing can result in dose blurring, interplay or interference effects which may cause a considerable deviation between the prescribed and delivered dose. Here, we investigated the per fraction dose effects by high-spatial resolution measurements.

**Material and Methods:** GaChromic EBT3 film measurements were carried out in the isocenter plane of a 3 cm diameter tumor in a movable cylindrical cedar lung insert (Quasar Phantom). The motion was in the cranial-caudal direction. Motion frequencies were 10 and 15 breaths per minute (bpm), and amplitudes were 10 and 20 mm. Volumetric modulated arc therapy (VMAT) plans for both 6 MV (600 MU/min) and 6 MV flattening filter free (FFF) (1400 MU/min) beams were created for each amplitude. The gross tumor volume including motion (GTV-IM) generated from a most intensive projection of a 4D CT, was prescribed a mean dose of 22.5 Gy. The GTV-IM was enclosed by the 90 % isodose. The motion effects on the GTV-IM were quantified biologically using the generalized equivalent uniform dose (gEUD, a=-10), and dosimetrically by the mean (Dmean) and minimum dose (Dmin). All deviations are given relative to the corresponding planned parameters. Static measurements were performed for each beam and amplitude and served as a baseline.

**Results:** For the static 10 mm amplitude cases, the relative deviation in gEUD was +0.2% (6 MV) and -1.6 % (6 MV FFF), Dmean = 0.4 and -0.7%, and, Dmin = 1.6 and -3.5%. For the 10 and 15 bpm and 10 mm amplitude, the reduction in the gEUD ranged between -1.8 and -3.2%. A similar trend in Dmean between -0.8 and -2.6% was observed and Dmin about -10%. The largest relative reduction in gEUD of -7.5% was observed for the 20 mm amplitude and 15bpm for the 6 MV FFF beam. Dmean and Dmin were -4.2 and -21.4% for this case, respectively.

**Conclusion:** This phantom study indicates that VMAT treatment in free breathing for lung SBRT tumors could lead to 3% under dosage in tumor gEUD for a motion amplitude of 10 mm and 7.5% for a 20 mm amplitude. Tumor movements of more than 10 mm for this treatment technique should consequently be avoided.

**EP-1772**

Comparison of dynamic 2D MRI with 4DCT lung tumors volumes for accurate real time imaging on linac-MR

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**Purpose or Objective:** The hybrid linac MR system is capable of acquiring 2D images at 4 frames per second during radiation delivery. Moving lung tumours can potentially be localized, in real time, by automatic contouring of these images, allowing radiation to “track” the tumour. This study aimed to compare the accuracy of the dynamic 2D MRI of a linac-MR for lung tumour delineation to 4-dimensional computed tomography (4DCT), the current standard for radiotherapy planning for lung cancer treatment.

**Material and Methods:** A total of five non-small cell lung cancer patients with tumours under 5 cm in size undergoing stereotactic body radiotherapy were recruited for this study. A planning 4DCT with 3 mm slice thickness was acquired for each patient using a belt system and retrospectively sorted into 10 bins, each assumed to estimate the actual size of the target in ten respiratory phases. Three of these bins representing end inhale, end exhale and mid-cycle, along with the motion encompassing maximum intensity projection (MIP), were contoured on axial slices by a radiation oncologist using the Computation Environment for Radiotherapy Research (CERR) platform (default lung window). The same patients were scanned using a Philips 3T MRI on a single 20 mm sagittal slab using a balanced SSFP sequence (TE/TR = 1.1/2.2ms, Pixel Size 3x3mm, 4fps) with the patient undergoing free breathing for 3 minutes (650 images). A radiation oncologist, using the CERR platform, with the default MR window, contoured these 650 sagittal