Conclusion: Severe reductions in target dose coverage were observed as an effect of interfractional anatomical changes. The difference between the position verification methods was a lesser issue compared to the effect of the anatomical changes.

Purpose or Objective: The new ESTRO consensus guideline for target delineation for elective breast radiotherapy (Offerens Radiother Oncol. 2015) establish the humeral head and connective tissues 10 mm around it as Planning Risk Volume (PRV). The objective was to implement these guidelines for sparing the humeral head in elective breast radiotherapy with level 1 and 2 (L1/L2) lymph nodes by comparing three different planning techniques.

Material and Methods: Ten patients with left-sided breast cancer were enrolled in a planning study performed in Pinnacle3 v9.8 (Philips). All patients were planned with 16 x 2.66Gy on the breast (PTVp) and the elective L1/L2 lymph nodes (PTVn). We compared three techniques: IMRT with high tangential field (HTF), 6-field IMRT and VMAT. The humeral head PRV (hh+10) was included with an objective of V40Gy < 1cc for all three techniques. Treatment plans were obtained with the inverse planning tool and optimization was achieved by decreasing the dose to the organs at risk (OARs; lungs, heart and right breast) as low as possible while maintaining a PTVp V95% of 97% and PTVn V90% of 95%.

For the high tangential fields, the cranial border of the fields was extended to include PTVn. The leaves of the 5 mm multi leaf collimator were then closed to exclude hh+10 to reduce the dose to the humeral head and the surrounding tissue. This technique is currently used in our clinic. The 6-field IMRT technique consisted of tangential fields and four additional fields (at 330, 20, 80 and 170 degrees) to ensure proper coverage of the cranial part of the breast and the lymph nodes. The cranial border of the tangential fields and caudal border of the four additional fields was set 1cm below the attachment of the clavicle at the sternum. The third technique was a VMAT dualarc from 305 to 180 degrees.

Results: HTF resulted in an average PTVp V95% of 97.2% and an average PTVn V90% of 90.4% (see Table 1). With the additional fields of the 6-field IMRT technique, the coverage of the lymph nodes increased significantly to on average 98.0% (p < 0.01) while PTVp did not vary significantly (p = 0.92). The doses to the OAR were comparable between the HTF and IMRT technique. The coverage of PTVn increased when using VMAT to an average of 99.5% (p < 0.01 compared to HTF and p = 0.19 compared to IMRT). The dose to the OAR increased as well. The mean dose to the contralateral breast increased significantly from 0.66Gy with HTF and IMRT to 2.3Gy with VMAT (p < 0.01 for both).

<table>
<thead>
<tr>
<th></th>
<th>HTF</th>
<th>IMRT</th>
<th>VMAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTVp V95% (%)</td>
<td>97.2 (91.8 - 99.5)</td>
<td>97.1 (96.8 - 97.3)</td>
<td>97.8 (96.6 - 97.4)</td>
</tr>
<tr>
<td>PTVn V90% (%)</td>
<td>90.4 (73.7 - 98.7)</td>
<td>98.0 (85.9 - 99.0)</td>
<td>99.5 (98.2 - 99.9)</td>
</tr>
<tr>
<td>hh+10 V40Gy (%)</td>
<td>0.46 (0.1 - 0.3)</td>
<td>0.67 (0.1 - 1.83)</td>
<td>0.70 (0.1 - 1.35)</td>
</tr>
<tr>
<td>Lungs Dmean (Gy)</td>
<td>4.7 (3.9 - 6.1)</td>
<td>4.8 (3.8 - 5.9)</td>
<td>5.2 (4.2 - 6.8)</td>
</tr>
<tr>
<td>Heart Dmean (Gy)</td>
<td>3.3 (1.6 - 6.1)</td>
<td>2.9 (1.6 - 5.7)</td>
<td>3.6 (2.8 - 5.7)</td>
</tr>
<tr>
<td>Right breast Dmean (Gy)</td>
<td>0.6 (0.3 - 0.9)</td>
<td>0.6 (0.3 - 0.7)</td>
<td>2.3 (0.6 - 4.2)</td>
</tr>
</tbody>
</table>

Conclusion: The humeral head and surrounding tissues as defined in the new ESTRO guideline can be spared with the 6-field IMRT or VMAT technique. It is not possible through high tangential fields without reducing PTVn coverage. A 6-field IMRT technique including tangential fields and four additional fields to cover the lymph nodes and the cranial part of the breast leads to adequate coverage of the primary target and the lymph nodes without increasing the dose to the other OARs.

PO-0848

Simultaneous integrated protection (SIP): a new concept for high precision radiation therapy
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Purpose or Objective: Stereotactic radiotherapy near critical serial organs at risk (OAR) requires specific caution to avoid severe toxicity. Current strategies are to (1) to rule out SBRT as a treatment option, (2) to use full dose SBRT and expose patients to higher risks, (3) to homogenously underdose the entire planning target volume (PTV), or (4) to trim PTV margins individually and non-quantifiably. We here describe a novel IMRT prescription method termed simultaneous integrated protection (SIP) for quantifiable and comparable dose prescription to targets very close to dose limiting structures. This work will be focussed on the planning of SBRT.

Material and Methods: For patients with infringement of dose constraints to at least one serial OAR, e.g. central airways, bowel, we defined a planning risk volume (PRV). The intersection volume of the PRV with the total planning target volume (PTV_Σ) was defined as the protection PTV_SIP and the vast non-intersecting majority of PTV_Σ as the dominant PTV (PTV_dom). Radiotherapy treatment planning was performed using IMRT. Dose was prescribed to PTV_dom according to ICRU in 3, 5, 8 or 12 fractions. If in doubt, preference to a higher number of fractions was given as a function of the size of PTV_SIP. D_max was allowed to be up to 130% of the prescribed dose. No specific dose was prescribed to the PTV_SIP but dose was required to stay within the constraints for the respective OAR. Dose-volume-histogram (DVH) analysis was based on absolute volumes of OARs, not on PRVs.

Results: This method led to a fall off region within PTV_SIP between the PTV_dom and the OAR. We here demonstrate this approach for six patients. Two had lesions in the chest, one in the liver, two in the pancreas and one in the left kidney (Figure 1). Size of the PTVs (PTV_Σ) ranged from 14.5 to 84.9 mL (median 49.2 mL, mean 49.7 mL; Figure 2). Sizes of PTV protection subvolumes (PTV_SIP) ranged from 1.8 - 3.9 mL (median and mean 2.8 mL). Relative PTV_SIP ranged from 2.9% - 13.4% of the size of PTV_Σ (median 7.4%). Noteworthy, the largest ratio, 13.4%, was an absolute volume of 2 mL, only. D_max of the PTV_SIP was significantly lower in patients...
1, 2 and 6 due to air within the PTV_SIP volumes compared with the other patients. Safety of the plans was analysed from the absolute volume DVHs (dose to mL). The steepness of dose fall off could be read off by the comparing the doses to the PRVs with those to the OARs. The constraints were respected for the corresponding OARs. All patients had local control at a median follow-up of 9 months and toxicity was low.

Conclusion: SIP-IMRT is shown to result in a median dose of ≥100% to PTV_Σ, to achieve high local control and low toxicity. Longer follow-up is required for verification of these results and a prospective clinical trial is currently testing this new approach in chest and abdomen SBRT.

PO-0849
Heart structures sparing through volumetric modulated arc therapy in mediastinal Hodgkin lymphoma
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Purpose or Objective: Within the frame of further implementing a precise dose delivery in young patients with mediastinal Hodgkin lymphoma, heart sparing appears a crucial endpoint. Recent studies demonstrated a correlation between the occurrence of various late events (e.g. heart failure, myocardial infarction, valve disease) and the dose received by different cardiac substructures, giving insights into a complex mechanism of radiation-induced toxicity. The purpose of this study was to compare the dose received by these substructures either using an optimized multi-arcs volumetric arc therapy (VMAT) or classical 3D-CRT.

Material and Methods: We analyzed the plans of 14 patients (3 males and 11 females) with stage I-IIA mediastinal disease without axillary involvement, treated with involved site radiotherapy; 11 had a bulky presentation at diagnosis. In every patient, a deformable fusion was performed with a dedicated software (Velocity™, Varian) between the planning CT scan and the pre-radiotherapy contrast enhanced CT scan. The following structures were delineated: whole heart; left main, left descending, circumflex and right coronary arteries; aortic, pulmonary, mitral and tricuspid valves; right and left atria; right ventricle, left ventricle and inter-ventricular septum; left ventricular apex, mid cavity, base and lateral wall. Two experienced radiation oncologists contoured target volumes (CTV) and heart structures, after a training session with a cardiologist and a heart radiologist. 3DCRT was planned as AP-PA, while the VMAT approach consisted of multi non-coplanar arcs (the so-called butterfly technique). Mean and max dose received by the single substructures were compared by Student’s T test.

Results: Mean and max doses for the different cardiac structures, according to the technique used, are reported in table 1. Maximum dose resulted similar for almost all the structures except for the whole heart and the right ventricle, where VMAT gave higher doses (probably due to small hotspots in the PTV areas adherent to heart segments, mainly located in the lower anterior mediastinum). Conversely, a lower mean dose was delivered by using VMAT to all structures, reaching a strong significant difference for whole heart (p = 0.025), aortic valve (p<0.0001), mitral valve (p=0.049) and left atrium (p<0.0001). Most significant findings are illustrated in figure 1.

<table>
<thead>
<tr>
<th>Structure</th>
<th>VMAT Minimum Dose (Cr)</th>
<th>VMAT Maximum Dose (Cr)</th>
<th>3D-CRT Minimum Dose (Cr)</th>
<th>3D-CRT Maximum Dose (Cr)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apex</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
<td>0.054</td>
</tr>
<tr>
<td>Right Atrium</td>
<td>12.8</td>
<td>12.8</td>
<td>12.8</td>
<td>12.8</td>
<td>0.007</td>
</tr>
<tr>
<td>Left Atrium</td>
<td>10.2</td>
<td>10.2</td>
<td>10.2</td>
<td>10.2</td>
<td>0.021</td>
</tr>
<tr>
<td>Right Coronary</td>
<td>22.8</td>
<td>22.8</td>
<td>22.8</td>
<td>22.8</td>
<td>0.044</td>
</tr>
<tr>
<td>Left Coronary</td>
<td>19.9</td>
<td>19.9</td>
<td>19.9</td>
<td>19.9</td>
<td>0.026</td>
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<tr>
<td>Right Ventricle</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
<td>0.016</td>
</tr>
<tr>
<td>Left Ventricle</td>
<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
<td>0.052</td>
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<tr>
<td>Right Aortic Valve</td>
<td>2.9</td>
<td>2.9</td>
<td>2.9</td>
<td>2.9</td>
<td>0.027</td>
</tr>
<tr>
<td>Left Aortic Valve</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>0.003</td>
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<tr>
<td>Right Pulmonary Valve</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>0.041</td>
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<tr>
<td>Left Pulmonary Valve</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
<td>0.008</td>
</tr>
<tr>
<td>Right Tricuspid Valve</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
<td>0.017</td>
</tr>
<tr>
<td>Left Tricuspid Valve</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>0.049</td>
</tr>
</tbody>
</table>

Conclusion: In this preliminary dosimetric comparison, optimized multi arcs VMAT was able to significantly reduce the mean dose to crucial heart substructures such as aortic valve, with a generalized reduction in mean doses received.