

Supplementary Material

Supplement S1

Table E1: Dose constraints according to XXX guidelines

Target structures	Dose constraint	Major deviation
PTV	$V_{25\text{Gy}} \geq 95\%$ $D_{2\%} \leq 32.5 \text{ Gy}$	$V_{25\text{Gy}} < 90\%$ $D_{5\%} > 32.5 \text{ Gy}$
PTV-CTV	$D_{\text{max}} \leq 30.0 \text{ Gy}$	$D_{2\%} > 30.0 \text{ Gy}$
CTV	$D_{\text{max}} \geq 30.0 \text{ Gy}$	
Cardiac substructures		
Aorta	$D_{\text{max}} \leq 20.0 \text{ Gy}$	$D_{\text{max}} > 25.0 \text{ Gy}$
Left coronary arteries	$D_{\text{max}} \leq 14.0 \text{ Gy}$	$D_{\text{max}} > 20.0 \text{ Gy}$
Vena cava superior	$D_{50\%} \leq 0.6 \text{ Gy}$	
Left atrium	$D_{\text{max}} \leq 4.4 \text{ Gy}$	
Heart without PTV	$D_{50\%} \leq 5.0 \text{ Gy}$	

Supplement S2

Table E2: Score of radiotherapy treatment planning study guidelines (RATING)

RATING score sheet		Points	Applicable/ relevant	Answer yes
Questions for the Introduction				
<i>The study aim formulated by research questions</i>				
1	Does the study have a concise and precise study aim, defined with a restricted number of interconnected questions?	10		☒
<i>The motivation for the research questions</i>				
2	Has relevant up to date literature been included to support the need for the current study?	5		☒
3	Does the study address an existing knowledge gap?	10		☒
Questions for Materials and Methods				
4	Is the global study design adequate for answering the posed research questions?	10		☒
5	Is the global study design described in sufficient detail for others to interpret and reproduce the results?	5		☒
<i>Patient cohort</i>				
6	Are the inclusion and exclusion criteria of the patient cohort described?	1	☒	☒
7	Is the clinical patient information of the cohort presented, including disease type, site(s) and clinical staging?	1	☒	☒
8	Is the included number of patients stated, explained and justified?	1	☒	☒
9	Has there been consideration of the need for ethical and/or legal approval for the study and if needed, is there a statement about this?	5		☒
<i>Imaging procedures</i>				
10	Have the scanning parameters been reported in sufficient detail (image modalities, equipment model, slice thickness, voxel size, patient position (e.g. head first, supine, etc.) etc.)?	1	☒	☒
11	Has the applied immobilisation equipment been described, (e.g. vendor and type, standard settings, etc.) where relevant?	1	☒	☒
<i>Treatment machine and settings</i>				
12	Have the treatment machine and relevant parameters been described with sufficient detail (model, beam energy, MLC, etc.)?	1	☒	☒
13	Have the monitor unit reference conditions been defined, where relevant?	1	☒	☐
<i>Definition of targets and OARs</i>				
14	Has GTV definition been described in sufficient detail, with references if possible?	1	☐	☐
			☒	

1 5	Has CTV definition been described in sufficient detail, with references if possible?	1		☒
1 6	Has the establishment of PTVs (or alternatively robustness settings) been described in sufficient detail?	1	☒	☒
1 7	Have PTV sizes in the patient cohort been described?	1	☒	☒
1 8	Have OAR definitions been described in sufficient detail, with references if possible?	1	☒	☒
1 9	Have PRV margins been described in sufficient detail, with references if available?	1	☒	☐
Treatment planning system and dose calculation				
2 0	Have all applied dose calculation algorithms been described in sufficient detail?	1	☒	☒
2 1	For any commercial software used, have the manufacturer, algorithms and specific versions been stated?	1	☒	☒
2 2	Have all relevant user parameters and settings in the TPS been reported, e.g. beams, dose grid, control point spacing?	1	☒	☐
2 3	Have all volumes been evaluated with the same software/methodology?	1	☒	☒
Planning aims and optimisation				
2 4	Are clear planning aims defined, including imposed hard constraints and planning objectives (with or without soft constraints)?	5		☒
2 5	Has the ranking of planning objectives (priorities) been described?	5		☐
2 6	Is the dose prescription clearly defined?	10		☒
2 7	Is there a narrative description of the applied optimisation process, including the handling of all objectives with their ranking?	5		☒
2 8	If manual intervention during or after optimisation is allowed, has this been described?	1	☐	☐
Bias mitigation				
2 9	Have enough study details been provided such that bias issues could be noted?	5		☒
3 0	Has bias been sufficiently mitigated to reliably answer the posed research question?	10		☒
Plan acceptability – minor and major protocol deviations				
3 1	Was the procedure for assessment of plan acceptability well-described?	1	☒	☒
3 2	Was the procedure for assessment of minor and major protocol deviations well described?	1	☒	☒
Plan (re-)normalisation for plan comparisons				
3 3	Has plan (re-)normalisation been described sufficiently?	1	☒	☐
Dose-volume parameters for plan evaluation and comparison				

3 4	Have sufficiently comprehensive dose-volume parameters been used for plan evaluations and comparisons?	5		☒
<i>Population-mean DVHs</i>				
3 5	Has the algorithm for creating population-mean/median DVHs been reported?	1	☐	☐
3 6	Have the definitions of confidence intervals been included?	1	☐	☐
<i>Plan evaluations by clinicians</i>				
3 7	Have clinicians scored plans to assess quality?	1	☒	☐
3 8	Were plan comparisons by clinicians blinded?	1	☐	☐
<i>Predicted tumour control probability and normal tissue complication probabilities for plan evaluation and comparison</i>				
3 9	Have any applied TCP models been described and referenced?	1	☐	☐
4 0	Have any applied NTCP models been described and referenced?	1	☐	☐
<i>Plan deliverability and complexity</i>				
4 1	Have methods used to assess plan deliverability and complexity been described in sufficient detail?	1	☒	☐
<i>Composite plan quality metrics</i>				
4 2	Is there a sufficient basis (e.g. in the literature) for any selected composite plan quality metrics?	1	☒	☒
4 3	Is there an adequate description of the calculation of the composite plan quality metrics?	1	☒	☒
<i>Planning and delivery times</i>				
4 4	Has measurement of planning times been described in sufficient detail?	1	☒	☐
4 5	Has the establishment of delivery times been described in sufficient detail?	1	☒	☒
<i>Statistical analysis</i>				
4 6	Have proper statistical methods been used and described in sufficient detail?	5		☐
4 7	In case of multiple testing for research questions, has this been handled appropriately?	1	☐	☐
Questions for Results				
4 8	Does the provided data contribute to (at least partly) answering all aspects of the research questions, e.g. plan acceptability, dosimetric quality, deliverability and planning and delivery times?	10		☒
<i>Dose distribution reporting</i>				
4 9	Are complete summaries of the dose distributions in the patient cohort provided (low doses, high doses, OARs, PTV, patient, etc.)?	5		☒

50	Are tables and figures optimised to clearly present the results obtained?	1	☒	☒
51	Have the answers to the research questions been illustrated for an example patient by providing dose distributions, DVHs, etc.?	1	☒	☒
<i>Plan acceptability reporting – minor and major protocol deviations</i>				
52	In case of treatment technique or planning technique comparisons, was plan acceptability reported separately for each technique?	1	☒	☒
53	Has plan acceptability been reported in sufficient detail: how many plans were acceptable, how many were not and for what reasons (e.g. violation of hard constraints, violation of soft constraints, other reasons)?	1	☒	☒
54	Was there adequate reporting of minor and major protocol deviations?	1	☒	☒
<i>Deliverability and complexity reporting</i>				
55	Has the deliverability of the plans been adequately reported?	1	☒	☐
56	Have plan deliverability and complexity been investigated in sufficient detail in relation to the posed research questions?	1	☒	☐
<i>Planning and delivery times reporting</i>				
57	Have planning and delivery times been adequately evaluated and reported?	1	☒	☐
<i>Patient-specific analyses reporting</i>				
58	Is there sufficient description of inter-patient variations in the results presented?	1	☐	☐
59	Have outlier patients been reported and has any exclusion from population analyses been sufficiently motivated and explained?	1	☐	☐
<i>Statistical reporting</i>				
60	Are the p-values reported appropriately?	1	☐	☐
61	Are there confidence intervals for the appropriate parameters?	1	☐	☐
Questions for discussions				
62	Is there an overall interpretation of the data presented in the Results section as to how the posed research questions are answered?	10		☒
<i>Comparison with literature</i>				
63	Has the study been sufficiently discussed in the context of existing literature?	5		☒
<i>Clinical and statistical significance</i>				
64	Does the discussion focus on statistically significant results?	1	☐	☒

6	Is the potential clinical significance of the results clearly	5		
5	discussed (assuming practical application would be feasible)?			
<i>Clinical applicability of the study</i>				
			☒	☒
6		1		
6	Is future the clinical applicability sufficiently discussed?			
<i>Study limitations</i>				
6	Has the impact of the study limitations on the provided	10		☒
7	answers to the research questions been sufficiently discussed?			
<i>Future work</i>				
			☒	☒
6		1		
8	Has the potential future work arising from the study been discussed?			
Questions for conclusions				
6		5		☒
9	Do the presented conclusions represent answers to the posed research questions?			☒
7		5		☒
0	Are the conclusions fully supported by the results?			
7		5		
1	Are the conclusions a fair summary of all results?			
Questions for supplementary				
<i>Supplementary materials</i>				
7	Is the information presented in the supplementary material of sufficient relevance?	1	☒	☒
2				
7	Is the presentation of the included information of sufficient quality, including readability?	1	☒	☒
3				
7	Has sufficient underlying data been made available or a willingness to share data been indicated, within local data sharing restrictions?	5		☒
4				
RATING remarks				
				☒
7		5		☒
5	Is the RATING score added to the manuscript?			
7		1	☒	
6	Is the accompanying question table added to the cover letter or the supplementary material?			
RATING score		90%		
RATING fraction		183	of	203

Supplement S3: XXX planning procedure

1. VMAT arc setup:

- Patient with arms up:
 - 4 partial arcs from 290-130° CW and 130°-290° CCW
 - This was chosen to keep the beam paths through the patient short, 4 arcs allow for more freedom in optimization and modulation. Also it reduces interplay and motion effects over the treatment compared to fewer arcs.



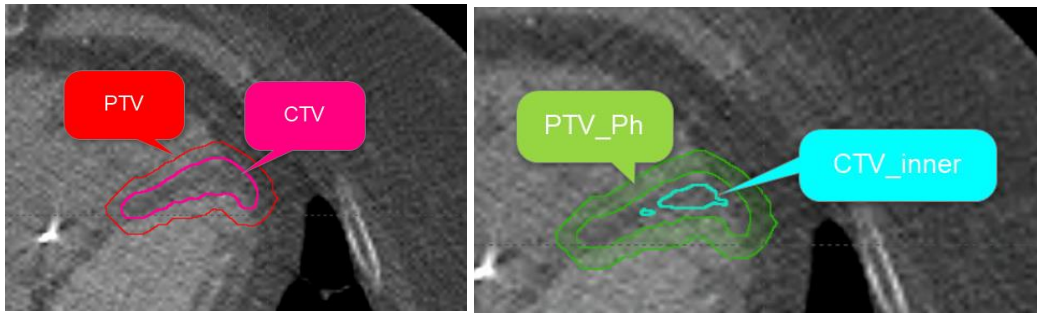
- Patient with arms down:
 - 4 partial arcs from 275-179° CW and 179-275° CCW with avoidance sector over the left arm
 - Arm needs to be avoided for correct dosage to the treatment target. To still have enough beam for modulation, arcs are longer than in the case with arms up.



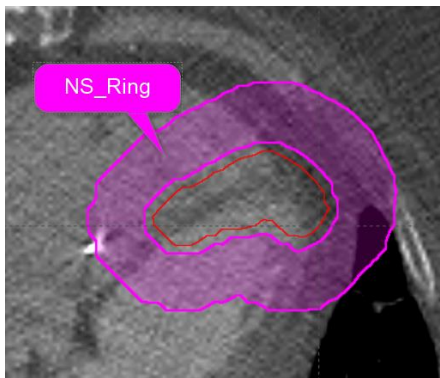
- 4 different collimator rotations +15°, -15°, +5°, +85°
- different collimator rotation to allow more freedom in optimization and modulation, especially one arc with collimator perpendicular to the others.

2. Tuning structures:

- 2 tuning structures for the dose distribution inside the PTV are generated:
 - $PTV_{Ph} = PTV - CTV$
 - $CTV_{inner} = CTV - 3 \text{ mm}$

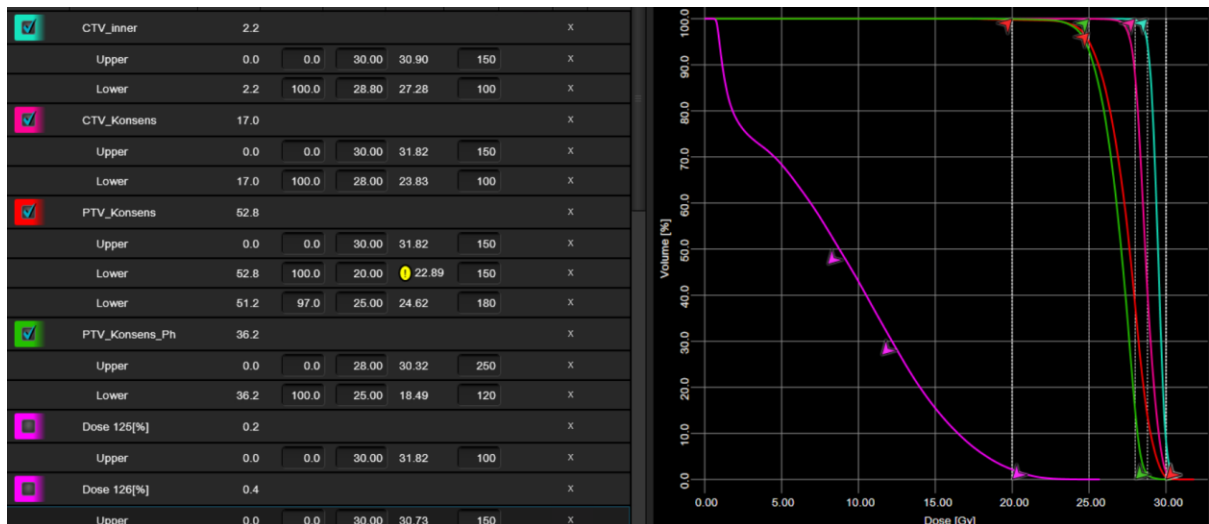


- A ring structure outside the PTV will be generated for dose conformity
 - $NS_Ring = (PTV + 23\text{ mm}) - (PTV + 3\text{ mm})$



3. Optimization procedure (PO 15.6.04):

- The PTV_Ph, CTV and CTV_inner are used to push on different dose levels in the target:
 - PTV_Ph: set min and max objectives to be within 100 - 112% (25 - 28 Gy)
 - CTV: set min and max objectives to be within 112 - 120% (28 - 30Gy)
 - CTV_inner: set min and max objectives to place the maximum dose central (29 - 30 Gy)
 - whole PTV: voluntary objectives to ensure minimal coverage and overall max dose



- The NS_Ring is used to generate a deep dose fall-off around the PTV, independent of OAR localization.
 - Use several objectives to push down the dose in the ring, especially keep pushing on the max dose, stop pushing just before you start losing PTV coverage.
- When your optimizer gives you a good result regarding PTV coverage and dose conformity, start adding OAR objectives:
 - For lungs, heart and ventricles use mean objectives, voluntary also max objectives (if structures are cropped from the PTV)
 - For esophagus, stomach and coronary arteries, use max objectives and push hard (increase the priority) until you reach the constraints.
- Adapt priorities and dose levels as the optimization continues to achieve all constraints.
- Local dose spillages or too high max dose can be contoured manually and pushed during a follow up optimization.
- As the RIVA is inside the PTV, but should only receive 20 Gy, a small compromise of PTV coverage is used. This is achieved by pushing the RIVA below 20 Gy, slightly loosening the minimum objective for the PTV at 25 Gy and adding an extra strong minimum objective for the PTV at 20 Gy. This will lead to a small undercoverage of the PTV, but only at the position of the RIVA. As this is a small amount of the overall PTV, still 95% of the PTV can be covered with the prescription dose (25 Gy).

