STOPSTORM Center Accreditation Program

Treatment Planning Benchmark - Instructions and Guidelines

Dear STOPSTORM members, Dear Participants,

Here you will find the instructions on how to perform the treatment plan for the benchmark study of the STOPSTORM.eu project.

Three cases are provided for this benchmark, and every case has a primary planning-CT and a contrast-enhanced CT. On those image sets, OARs and PTV are already contoured: please, use the already present structures for your planning. Despite this having been a mandatory exercise for the STOPSTORM.eu centers, which was subsequently published [1], please enjoy this as a learning experience in the same way as it was for the creators and participants of this benchmark.

[1] Refining Treatment Planning in STereotactic Arrhythmia Radioablation: Benchmark Results and Consensus Statement From the **STOPSTORM**.eu Consortium.
Trojani V, Grehn M, Botti A, Balgobind B, Savini A, Boda-Heggemann J, Miszczyk M, Elicin O, Krug D, Andratschke N, Schmidhalter D, van Elmpt W, Bogowicz M, de Areba Iglesias J, Dolla L, Ehrbar S, Fernandez-Velilla E, Fleckenstein J, Granero D, Henzen D, Hurkmans C, Kluge A, Knybel L, Loopeker S, Mirandola A, Richetto V, Sicignano G, Vallet V, van Asselen B, Worm E, Pruvot E, Verhoeff J JC, Fast M F, Iori M, Blanck O. Int J Radiat Oncol Biol Phys. 2025 Jan 1;121(1):218-229.

Instructions for Down-/ and Upload:

Please, use the ZENODO STOPSTORM Page for data download which contains the two CTs and structure sets for all three cases (all in DICOM format) and the papers referenced in this document:

ZENODO STOPSTORM Community: https://zenodo.org/communities/stopstorm/

Import the three cases into your treatment planning system including the RTstruct file. The planning CT and the corresponding cardiac-CT are already pre-registered using deformed image registration. Do not alter the registration, nor the imported structures. Additional control region structures can be created to help the user with the planning.

If you have any questions or issues regarding the treatment planning benchmark, feel free to contact Oliver Blanck (oliver.blanck@uksh.de) or Melanie Grehn (melanie.grehn@uksh.de).

General instructions

Cases description: targets delineation process (already performed)

For **case 1 and 2**, an electrocardiogram (ECG)-triggered CT with intravenous contrast agent was performed prior to the electroanatomical voltage mapping (EVM) procedure.
For each case, the VT substrate (target region for cardiac radioablation) was first defined by experienced electrophysiologists based on all provided clinical information, the most recent 12-lead ECG during VT, and/or all available electroanatomic map (EAM) data. Using the information from the high resolution EVM procedure and following interdisciplinary discussions between the involved specialists, the target area (in analogy to the clinical target volume in oncological cases) was delineated using different 3D views of various cardiac structures.

Regarding **case 1**, the contrast CT was co-registered to the planning 4D CT in order to clearly visualize the ventricle wall. The target was found in the septal region. An internal target volume (ITV) approach based on the planning 4D respiratory and the ECG-gated 4D cardiac CT was used to cover respiratory and cardiac motion. Finally, an isotropic margin of 5 mm was added to create the planning target volume (PTV) to account for delivery uncertainties based on standard practice.

For **case 2**, the position of the target was found in midventricular and apical antero-septal segments.

For **case 3**, diagnostic contrast-enhanced cardiac MRI examination was performed to localize the myocardial substrate. Simulation CT and 3-dimensional MRI were fused using non-rigid registration. The critical substrate was identified in the septal to anterolateral and basal to midventricular LV segments.

In **case 2 and 3**, an ITV approached based on the ECG-gated 4D cardiac CT was used to cover cardiac motion while respiratory motion was either tracked via an ICD lead (case 2) or gated via the diaphragm (case 3). Finally, an isotropic margin of 5 mm was added to create the planning target volume (PTV) to account for delivery uncertainties based on standard practice.

We have included in the downloadable the performed cardiac imaging, already registered for each case: this is not relevant in the planning phase, but it can be used in the plan evaluation process, if the clinical team deems it necessary.

Treatment planning (to perform)

For all of the three cases, the prescribed surrounding dose to the PTV is ***25 Gy** delivered in **1** fraction according to ICRU91* and in line with previous successful case reports [1, 2]. Aside from that, how the prescribed dose is achieved in the plan (i.e. prescription isodose surface volume and critical organs dose endpoints and constraints) is up to the individual clinical team from the different institutions. Our decision not to give specific planning constraints or objectives reflects the wish to have an unbiased view of the situation in all STOPSTORM consortium institutions.

Regarding critical structures doses, we recommend following international guidelines about stereotactic radiotherapy treatments. Some examples are NCCN guidelines for Non-Small Cell Lung Cancer treatments [3], which focuses on critical structures dose recommendations for organs in the thorax district, the AAPM report Task Group 101: Stereotactic body radiation therapy [4], or Gerhard et al.'s systematic review about dose constraints in SABR clinical trial [5].

Doses to critical sub-structures do not exhibit a large literature showing correlations to treatment toxicity effects. Stam et al. found two dosimetric parameters associated to the *left atrium* and *superior vena cava (SVC)* which showed a significant Cox regression association with non-cancer death in NSCLC patients treated with stereotactic treatments [6].

Chan et al. [7] also reported that NSCLC patients' overall survival (OS) outcomes were higher if *V10Gy < 0.04 for the right ventricle* for stereotactic treatments delivering a biologically effective dose (α/β = 10 Gy) of 151.2 Gy.

Furthermore, as an additional recommended guideline, we suggest a summary of the dose limits/recommendations included in the RAVENTA trial [8], which is a clinical trial for STAR treatments.

References

[1] Blanck, O., Buergy, D., Vens, M. et al. Radiosurgery for ventricular tachycardia: preclinical and clinical evidence and study design for a German multi-center multi-platform feasibility trial (RAVENTA). Clin Res Cardiol 109, 1319–1332 (2020). https://doi.org/10.1007/s00392-020-01650-9

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[6] Stam B, Peulen H, Guckenberger M, Mantel F, Hope A, Werner-Wasik M, Belderbos J, Grills I, O'Connell N, Sonke JJ. Dose to heart substructures is associated with non-cancer death after SBRT in stage I-II NSCLC patients. Radiother Oncol. 2017 Jun;123(3):370-375. doi: 10.1016/j.radonc.2017.04.017. Epub 2017 May 2. PMID: 28476219.

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