

Are the Radiation Therapy Published Dose Constraints for Aorta and Major Vessels Valid?

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Abstract

Objectives: Understanding dose constraints for critical structures in stereotactic body radiation therapy (SBRT) is essential for patient safety. Published dose constraints are derived by a variety of methods, including crude statistics, actuarial analysis, modeling, and simple biologically effective dose (BED) conversion. Because published constraints are inconsistent, without the discrimination of all the factors involved safe treatment could be compromised.

Methods: A logistic dose-response model is provided for aorta and major vessels based on 625 cases, comprised of data from 238 published major vessel contours (Nishimura et al. JTO 2014 Sep;9(9):1370-6) and 387 cases from MD Anderson Cancer Center at Cooper University Hospital, primarily in 3-5 fractions. No CTCAE grade 3-5 major vessel complications occurred in our patients so we performed an aggregate analysis of the published dataset that had three complications with our patient population to gain an initial estimate of risk. The median number of fractions was 5, so all doses were converted to 5-fraction equivalent dose using the linear quadratic model with $\alpha/\beta=3\text{Gy}$. The dose volume histogram (DVH) data was loaded into the DVH Evaluator software (DiversiLabs, LLC, Huntingdon Valley, Pa, USA) and maximum-likelihood parameter fitting of the logistic model was performed.

Results: For the major vessel maximum point dose (Dmax), the fitted logistic 50% tolerance dose (TD50) was 81.0 Gy in 5 fractions and the slope parameter was $\gamma_{50}=3.1301$. From this model, the Radiation Therapy Oncology Group (RTOG) 0813 dose-tolerance limit of Dmax=52.5Gy in 5 fractions was found to have a 1.2% risk of grade 3-5 toxicity, and the Timmerman 2008 limit of Dmax=45Gy in 3 fractions had 2.3% risk. A DVH Risk Map was constructed by graphing published dose tolerance limits with their estimated risk levels and overlaying the clinical dataset. From the model, the 1% and 2% risk levels for D4cc, D1cc, and D0.5cc are also determined for 3-5 fractions, and included in the DVH Risk Map providing safe limits.

Conclusions From the DVH Risk Map including clinical outcomes data, published dose tolerance limits, and risk levels estimated from dose response modeling, we validated a set of safe limits for major vessels in 3 to 5 fractions, with about 2% risk for high-risk limits and about 1% risk for low-risk limits.

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Abstract

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