Interdisciplinary Variation in Segmentation of High-Risk Post-Operative Tumor Volumes in the Head and Neck

Brandon A. Dyer B.S., Musaddiq J. Awan M.D., Mark Zafereo M.D., Carol Lewis M.D., Nandita Guha-Thakurta M.D., J. Matthew Debnam M.D., G. Brandon Gunn M.D., Jack Phan M.D. PhD., David I. Rosenthal M.D., Clifton D. Fuller M.D. PhD.

THE UNIVERSITY OF TEXAS MD Anderson Cancer Center

OREGON HEALTH & SCIENCE UNIVERSITY

Introduction

Intensity Modulated Radiotherapy (IMRT) is a conformal radiation technique enabling the generation of steep dose gradients within complex geometries. [1] The widespread adoption of this modality has resulted in improved ROI delineation and sparing of Organs at Risk (OAR), ultimately resulting in sparing of normal tissues and improved tumor targeting, patient outcomes and toxicity profiles. [2] A shift from traditional two-dimensional (2D) treatment to use highly conformal IMRT treatment plans has greatly reduced concurrent and late-onset toxicity sequelae. However, this problem continues to be a challenge as even minor variability in treatment setup and/or execution may result in massive, devastating over-dosage of surrounding normal tissues. [3] Modern evaluation and treatment of head-and-neck cancer patients typically involves, and is dependent upon, the collective, coordinated expertise of multidisciplinary care teams (MCT) with heavy input coming from radiologic, surgical and radiation oncologic specialties. The MCT has become widely accepted as “best practice,” having demonstrated measureable improvements in clinical quality indicators (CQI). [4-6]

In this setting, several things are important to note:

1. Target delineation in post-operative radiation therapy (PORT) for head and neck cancer (HNC) is complex.

2. Distortion of normal anatomy, reconstruction, potential for tumor seeding, and interpretation of the location of surgical margins may confound target delineation.

3. Collaboration between radiation oncologists, surgeons and head and neck radiologists is necessary to identify the exact areas at risk for CTV assignment.

The specific aim of this study was to evaluate the differences in delineation of region of interest (ROI) target volumes in patients receiving PORT for HNC.

Technique

Clinical information and planning CT scans for three patients receiving post-operative radiation therapy (PORT) for HNC were anonymized and used for ROI delineation.

After receiving a standardized set of explicit instructions two radiation oncologists (RO) specializing in HNC, two head-and-neck surgeons (HNS), and two head-and-neck radiologists (HNR) manually contoured four high-risk ROIs, including: pre- and post-operative GTV and tumor bed, respectively and pre- and post-operative nodal GTV and nodal bed, respectively, using DICOM images on Pinnacle v9.0 treatment planning software (TPS).

As most users were unfamiliar with the software interface, a skilled Pinnacle user was present throughout the contouring process to answer software interface questions only.

Physicians were allowed access to all patient records including pre-operative imaging and any operative, pathologic or clinical note relevant to their task excluding the ultimate radiation treatment plan or planning notes.

Bivariate analysis was performed using JMP v.10 software package (SAS Institute; Cary, NC) with non-parametric statistical tests used at $\alpha = 0.05$.

Results

Average overlap (Dice Similarity Coefficient, DSC) of ROIs was greater between physicians of the same specialty (SS) as compared to those between physicians of different specialties (DS):

Mean SS DSC overlap: 55.6% $\pm$ 18.1% vs. Mean DS DSC overlap: 38.4% $\pm$ 18.2%. Additionally, there was a significant difference in voxel target volume between specialties for ROIs at the primary site:

ROs: 33384, HNSs: 47019, HNRs: 11840, p = 0. 0019

In the diseased neck:

ROs: 24033, HNSs: 45575, HNRs: 6580, p = 0.0030.

The specific difference between the HNRs and each of the other two specialties (ROs, HNSs) was significant under Bonferroni corrected multiple comparisons. ($p < 0.05/3$).

Conclusions

Radiation oncologists using IMRT photon treatment planning systems operate under a well-defined, standardized set of clinical definitions arising from the International Commission on Radiation Units (ICRU) sixty-second report, which is meaningless and unfamiliar to those not in this field. While the fields of neuroradiology and HNS are somewhat inter-dependent, the degree to which radiation medicine depends on both is substantially greater. This makes exact, fluid and homogenous communication paramount in defining institutional practices that maximize the benefit of clinical treatment. Great variability exists in interdisciplinary understanding of areas of high-risk microscopic disease amongst head and neck surgeons, diagnostic radiologists and radiation oncologists. Previous data has suggested the benefit of collaborative radiation therapy quality assurance with multiple radiation oncologists. Our data suggest that interdisciplinary collaboration for the delineation of PORT target volumes warrants further investigation.

Acknowledgments

Mr. Dyer received grant/funding support from the Rubinstein Radiation Research Scholar Program, the Student Senate and Office of the Dean at OHSU. Dr. Fuller received/receives grant/funding support from the SWOG-Hope Foundation Dr. Charles A. Coltman, Jr. Fellowship in Clinical Trials, the National Institutes of Health Clinician Scientist Loan Repayment Program (L30 CA136381-02), Elekta AB (Stockholm, SE), the Center for Radiation Oncology Research at MD Anderson Cancer Center and the MD Anderson Institutional Research Grant Program.

References

1. Brahme, A., *Design principles and clinical possibilities with a new generation of radiation therapy equipment. A review.* Acta Oncol, 1987. **26**(6): p. 403-12.
2. Nutting, C.M., et al., *Parotid-sparing intensity modulated versus conventional radiotherapy in head and neck cancer (PARSPORT): a phase 3 multicentre randomised controlled trial.* Lancet Oncol, 2011. **12**(2): p. 127-36.
3. Emami, B., et al., *Tolerance of normal tissue to therapeutic irradiation.* International journal of radiation oncology, biology, physics, 1991. **21**(1): p. 109-22.
4. Al-Mamgani, A., et al., *The impact of treatment modality and radiation technique on outcomes and toxicity of patients with locally advanced oropharyngeal cancer.* Laryngoscope, 2013. **123**(2): p. 386-93.
5. Back, M.F., et al., *Improvements in quality of care resulting from a formal multidisciplinary tumour clinic in the management of high-grade glioma.* Ann Acad Med Singapore, 2007. **36**(5): p. 347-51.
6. Wheless, S.A., K.A. McKinney, and A.M. Zanation, *A prospective study of the clinical impact of a multidisciplinary head and neck tumor board.* Otolaryngol Head Neck Surg, 2010. **143**(5): p. 650-4.