Medical Dosimetry 41 (2016) 148–153

Medical Dosimetry

journal homepage: www.meddos.org

Split-field *vs* extended-field intensity-modulated radiation therapy plans for oropharyngeal cancer: Which spares the larynx? Which spares the thyroid?

Yao Yu, M.D.,[*] Josephine Chen, Ph.D.,[*] Celeste I. Leary, B.S.,[†] Erin Shugard, M.S.,[*] and Sue S. Yom, M.D., Ph.D.[*‡]

[*]*Department of Radiation Oncology, University of California, San Francisco, San Francisco, CA;* [†]*Department of Radiation Medicine, Oregon Health Sciences University, Portland, OR; and* [‡]*Department of Otolaryngology—Head and Neck Surgery, University of California, San Francisco, San Francisco, CA*

ARTICLE INFO

Article history:
Received 10 June 2015
Received in revised form
24 November 2015
Accepted 29 November 2015

Keywords:
Split field
Isocentric match
Extended field IMRT
Low-anterior neck field

ABSTRACT

Radiation of the low neck can be accomplished using split-field intensity-modulated radiation therapy (sf-IMRT) or extended-field intensity-modulated radiation therapy (ef-IMRT). We evaluated the effect of these treatment choices on target coverage and thyroid and larynx doses. Using data from 14 patients with cancers of the oropharynx, we compared the following 3 strategies for radiating the low neck: (1) extended-field IMRT, (2) traditional split-field IMRT with an initial cord-junction block to 40 Gy, followed by a full-cord block to 50 Gy, and (3) split-field IMRT with a full-cord block to 50 Gy. Patients were planned using each of these 3 techniques. To facilitate comparison, extended-field plans were normalized to deliver 50 Gy to 95% of the neck volume. Target coverage was assessed using the dose to 95% of the neck volume (D_{95}). Mean thyroid and larynx doses were computed. Extended-field IMRT was used as the reference arm; the mean larynx dose was 25.7 ± 7.4 Gy, and the mean thyroid dose was 28.6 ± 2.4 Gy. Split-field IMRT with 2-step blocking reduced laryngeal dose (mean larynx dose 15.2 ± 5.1 Gy) at the cost of a moderate reduction in target coverage (D_{95} 41.4 ± 14 Gy) and much higher thyroid dose (mean thyroid dose 44.7 ± 3.7 Gy). Split-field IMRT with initial full-cord block resulted in greater laryngeal sparing (mean larynx dose 14.2 ± 5.1 Gy) and only a moderately higher thyroid dose (mean thyroid dose 31 ± 8 Gy) but resulted in a significant reduction in target coverage (D_{95} 34.4 ± 15 Gy). Extended-field IMRT comprehensively covers the low neck and achieves acceptable thyroid and laryngeal sparing. Split-field IMRT with a full-cord block reduces laryngeal doses to less than 20 Gy and spares the thyroid, at the cost of substantially reduced coverage of the low neck. Traditional 2-step split-field IMRT similarly reduces the laryngeal dose but also reduces low-neck coverage and delivers very high doses to the thyroid.

Introduction

Intensity-modulated radiotherapy (IMRT) has been widely adopted for treatment of malignancies of the head and neck. In contrast to 3-field techniques that utilize 2 opposed lateral beams matched to an anteroposterior (AP) low-anterior neck (LAN) field, IMRT uses multiple beam angles to deliver highly conformal dose distributions. Using IMRT, treatment of the low neck can be accomplished either with extended-field IMRT (ef-IMRT) or split-field IMRT (sf-IMRT) with a LAN field carefully matched to avoid overlap on the spinal cord.

IMRT requires target delineation on cross sectional imaging. A consensus atlas sponsored by the Radiation Therapy Oncology Group (RTOG) is widely used to standardize IMRT target volumes, including delineation of the low neck.[1] Retrospective reviews have not demonstrated a difference in regional recurrence rates because of the shift from 3-field techniques to IMRT.[2] However, ef-IMRT coverage of low-neck volumes may result in increased dose to adjacent normal structures in the low neck that were previously spared using three-dimensional techniques.

Celeste I. Leary was supported by the Summer Undergraduate Fellowship Program of the American Association of Physicists in Medicine.

Reprint requests to: Sue S. Yom, M.D., Ph.D., Department of Radiation Oncology, UCSF 1600 Divisadero Street, Suite H-1031, San Francisco, CA 94143.

E-mail: yoms@radonc.ucsf.edu

http://dx.doi.org/10.1016/j.meddos.2015.11.003

Table

	Coverage		Larynx	Thyroid		
	D_{95} (Gy)	VS_{45} (%)	Mean (Gy)	Mean (Gy)	VS_{45} (cc)	NTCP (%)
ef-IMRT	50 ± 0.012	0.884 ± 0.63	25.7 ± 7.4	28.6 ± 2.4	8.61 ± 3	37.7 ± 22
Traditional sf-IMRT	41.4 ± 14 $p < 0.001$	3.07 ± 4.5	15.2 ± 5.1 $p = 0.0012$	44.7±3.7 $p < 0.001$	2.19 ± 1.7	77.7 ± 16
Full-cord block sf-IMRT	34.4 ± 15 $p < 0.001$	6.21 ± 4.5	14.2 ± 5.1 $p < 0.001$	31 ± 8 $p = 0.24$	5.95 ± 2.2	44.4 ± 22

The D_{95}, mean thyroid, and mean larynx dose were compared across techniques, using ef-IMRT as the reference arm. Comparisons were made with pairwise t-test, with statistical significance set at $p = 0.017$ to correct for multiple hypotheses using the Bonferroni method.
D_{95} = dose to 95% of RTOG-defined low-neck PTV; Mean = mean dose; NTCP = normal tissue complication probability, based on model reported by Rønjom *et al.*[7]; PTV = planning target volumes; VS_{xx} = volume spared xx Gy.

Increased doses to central normal structures, particularly the larynx, using ef-IMRT techniques are of particular concern.[3,4] The negative effects of radiation on the swallowing apparatus are well documented.[5,6] The thyroid is another structure in the central neck that abuts both the larynx and the nodal neck volume at risk. A dose-response effect for radiation-induced hypothyroidism has been documented at the dose level typically required for elective nodal treatment.[7-9]

In the present study, we evaluated the radiation dose delivered to the low-neck target volume, thyroid and larynx using the following 3 different low-neck treatment techniques: (1) ef-IMRT, (2) sf-IMRT with traditional cord-junction block followed by full-cord block, and (3) sf-IMRT with full-cord blocking throughout.

Methods and Materials

Patients

A total of 14 patients with cancers of the oropharynx were selected for this study. Patients were treated between June 2009 and November 2011 to a prescription dose of 66 to 70 Gy over 30 to 35 fractions. Among all, 7 patients received treatment using sf-IMRT matched at a horizontal plane set at the isocenter to an AP-LAN field, and 7 patients had treatment with ef-IMRT for all fractions. None of the patients had nodal disease at or below the level of the larynx. In this study, all 14 patients were replanned using each of the 3 methods described later.

Target and structure delineation

Gross tumor volumes, clinical target volumes, and planning target volumes were delineated by the treating physician. RTOG-defined volumes were drawn per previously published guidelines.[1]

The thyroid gland was anatomically delineated on the planning computed tomography. No standardized planning contours are accepted for the larynx. To enable comparison with previously published studies, the larynx was contoured from the superior-most extent of the aryepiglottic fold to the superior-most extent of the cricoid cartilage. The medial border of the thyroid cartilage was used to delineate the lateral margin of the larynx.[10] Representative contours are shown in Fig. 1.

Extended-field IMRT

Our institutional technique for ef-IMRT, including dose conventions and constraints, have previously been described in detail elsewhere.[11] For patients initially treated with the sf-IMRT technique, the low-neck target volumes were delineated and used for replanning purposes.

sf-IMRT with matched AP-LAN field

The sf-IMRT technique has been previously described in detail.[12] The treatment isocenter was placed just above the level of the arytenoids. The superior IMRT fields were half-beam blocked and matched at the isoplane to the inferior AP field treating the LAN. The inferior AP field was drawn on a digital radiograph reconstruction of the planning computed tomography, with the superior border at the isoplane, lateral border at the crossing of clavicle and the second rib (usually at 8 cm from midline), and inferior border just below the clavicles.

Multiple IMRT fields were used to address the superior components using the original target volumes and prescriptions. The inferior jaw was kept closed to minimize heterogeneity at the match line. The inferior treatment field was addressed with a single AP beam using a spinal cord-junction block or full-cord block. This inferior field was prescribed to 50 Gy in 25 fractions to a point located in the midsupraclavicular nodes at a depth of 3 cm. For the purposes of this study, the match line at the isoplane was not feathered or shifted. Representative block designs are shown on digitally reconstructed radiographs in Fig. 2.

In this study, 2 types of sf-IMRT plans were generated for each patient. In the traditional sf-IMRT technique, the low-neck AP-LAN field was initially planned for the first 40 Gy with a 3 cm (wide) × 4 cm (long) spinal cord-junction block (sometimes also called “cheater block” or “laryngeal block”), as the intention was to prevent any overlap of the IMRT and AP-LAN fields resulting in overtreatment of the spinal cord at the match line (horizontal isoplane). This initial block was created using vertical multileaf collimators, followed by a 3 cm wide vertically oriented full-cord (or “midline”) block that was used to create a second plan delivering the last 10 Gy to the low neck.

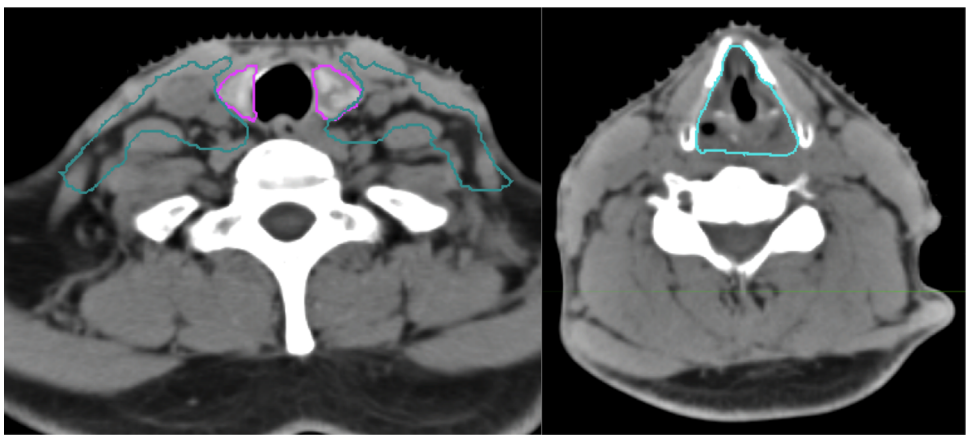

Fig. 1. Left: low-neck PTV is in blue. The thyroid is contoured in pink. Right: the larynx was contoured from the superior-most extent of the aryepiglottic fold to the superior-most extent of the cricoid cartilage. The medial border of the thyroid cartilage is the lateral boundary of the larynx. (Color version of figure is available online.)