

# Evolution of Cord Absorbed Dose during of Larynx Cancer Radiotherapy, with 3D Treatment Planning and Tissue Equivalent Phantom

Mohammad Hassan Heidari, Amir Hossein Goodarzi, Majid Azarniush

**Abstract**—Radiation doses to tissues and organs were measured using the anthropomorphic phantom as an equivalent to the human body. When high-energy X-rays are externally applied to treat laryngeal cancer, the absorbed dose at the laryngeal lumen is lower than given dose because of air space, which it should pass through, before reaching the lesion. Specially, in case of high-energy X-rays, the loss of dose is considerable. Three-dimensional absorbed dose distributions have been computed for high-energy photon radiation therapy of laryngeal and hypopharyngeal cancers, using a coaxial pair of opposing lateral beams in fixed positions. Treatment plans obtained under various conditions of irradiation.

**Keywords**—3D Treatment Planning, anthropomorphic phantom, larynx cancer, radiotherapy.

## I. INTRODUCTION

THE larynx is divided into the supraglottic, glottic, and subglottic regions. The supraglottic larynx consists of the epiglottis, the false vocal cords, the ventricles, and the aryepiglottic folds, including the arytenoids. The glottis includes the true vocal cords and the anterior commissure. The subglottis is located below the vocal cords. The ultimate goal of radiotherapy (RT) is the total eradication of tumors while minimizing the toxicity to the surrounding healthy structures.

Cancer of the larynx represents about 2% of the total cancer risk and is the most common head and neck cancer (skin excluded). Estimated New Cancer Cases and Deaths by Sex, in United States, 2013, there were approximately 13930 new cases of cancer of the larynx (11200 men and 2730 women) and about 3800 deaths from laryngeal cancer [1].

Irradiation for T1 or T2 vocal cord cancer is delivered by small portals covering only the primary lesion. The cervical lymph node chain is not electively treated. For T1 lesions, radiation therapy portals extend from the thyroid notch superiorly to the inferior border of the cricoid and fall off anteriorly. The posterior border depends on the posterior extension of the tumor [2]. For T2 tumors, the field is extended depending on the anatomic distribution of the tumor.

The field size ranges from 4×4cm to 5×5cm (plus an

additional 1cm of “flash” anteriorly) and is occasionally 6×6cm for a large T2 lesion. Portals larger than this increase the risk of edema without improving the cure rate.

A commonly used dose-fractionation schedule at many institutions is 66 Gy for T1 lesions and 70 Gy for T2 cancers given in 2-Gy fractions. Evidence suggests that increasing the dose per fraction may improve the likelihood of local control [3]-[5].

## II. MATERIAL & METHOD

All measurements were performed using a Primus linac (Siemens, Germany) established in the Hafte Teir Radiotherapy and Oncology, Shahre Ray, Tehran, Iran. The primus linac provides two low and high energy photon beams (6 and 15 MV) and a range of electron beams (5-12 MeV).

Thermoluminescent dosimeters (TLDs) were embedded at 18 measurement locations in slab no. 8 of a humanoid phantom and exposed to two lateral-opposed beams using standard small 8×8cm fields. Similarly, radiographic and radiochromic films were placed between slabs no. 7 and no. 8 of the humanoid phantom and exposed to two lateral-opposed radiation beams. The dosimeters were irradiated with 6 MV photon beams. Computer tomography (CT) treatment planning without inhomogeneity correction was performed.

## III. 3D TREATMENT PLANNING

Three-dimensional treatment planning systems allow for evaluation of dose distributions in multiple off-axis slices and calculations of dose using heterogeneity correction factors. Dose distributions can be modulated through standard wedge compensators or field-in-field techniques.

Conventional clinical treatment plans using two laterally opposed wedged photon beams were performed using the ISOGRAY TPS. The fields were 1cm “falling off” anteriorly, and the posterior border was at the anterior vertebrae. The prescribed dose to the “box” outlined by the treatment fields was 66 Gy at the 100% isodose, given in 33 fractions at six fractions weekly. The dose was calculated using the superposition CCC algorithm in Isogray.

Mohammad Hassan Heidari was with Departement of Radiation Oncology, Hafte teir Hospital, Shahre ray, Iran (Tel: +989125016760; e-mail: m.heidari2411@yahoo.com).

Amir Hossein Goodarzi, was with Departement of Radiation Oncology, Hafte teir Hospital, Shahre ray, Iran (Tel: +989122144484; e-mail: ahgoodarzy@yahoo.com).

Majid Azarniush is with the Islamic Azad University, VARAMIN Branch, Tehran, Iran (phone: +989123041300; hzz1390@gmail.com).

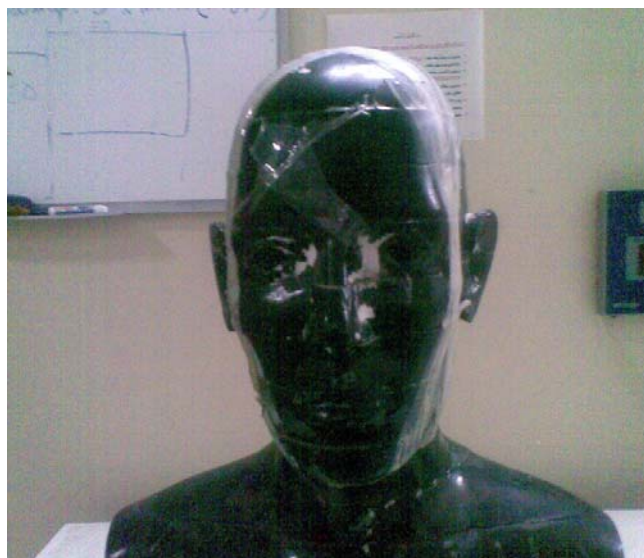


Fig. 1 Anthropomorphic phantom used for measurements

#### IV. TLD DOSIMETRY SYSTEM

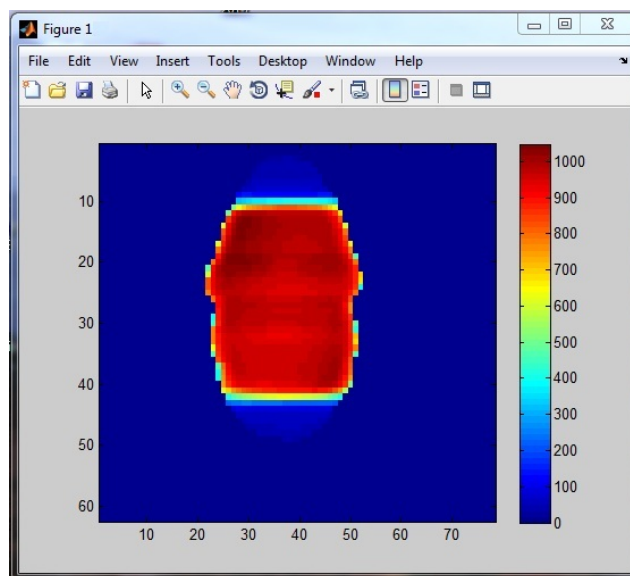
Absorbed dose measurements were made with thermoluminescence (TL) dosimetry. We used Lithium fluoride (LiF) Thermoluminescent Dosimeters (TLD-100) chips (3.7mm\*3.7mm\*0.9mm, manufactured by Harshaw, Solon, USA) Pre-irradiation annealing was carried out in 400C for 1 h, followed by cooling to room temperature. Each dosimeter was rinsed before being read out with a solution of methanol containing 12mmol HCl/l. The dosimeters were read out in 300C for 10s. Each dosimeter was individually calibrated. The calibration was carried out in a PMMA phantom with 5mm build up in a 60Co beam. The stability of the dosimeters was within  $\pm 3\%$ . The variation in the mass energy transfer coefficient in the energy interval for 6 MV, 60Co and 192Ir is less than 3%. This value was calculated from a standard textbook of TL dosimetry [6], [7].

#### V. GAFCHROMIC EBT FILMS

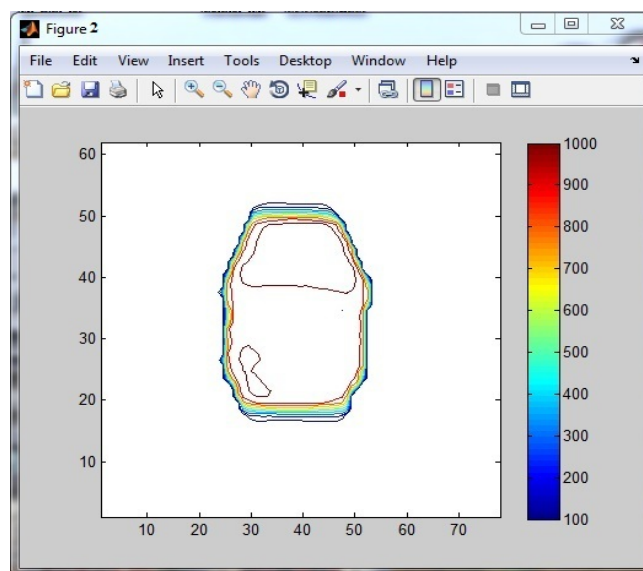
Radiochromic phenomena involve the direct coloration of a material by the absorption of radiation without the use of external chemical, optical or thermal agents. Radiochromic films are nearly transparent before irradiation and consist of a micro-crystalline active thin layer based on polydiacetylene, coated on a flexible polyester film base. After irradiation, their color changes to blue due to polymerization effects [8].

The internal structure of GafChromic EBT consists of two active layers of 17 $\mu$ m thickness separated by a 6 $\mu$ m layer coated on a 97 $\mu$ m polyester base on each side. This design decreases the effects of environmental and ultraviolet light [9]. The atomic composition of the film material is C (42.3%), H (39.7%), O (16.2%), N (1.1%), Li (0.3%) and Cl (0.3%) with an effective atomic number of 6.98. Its sensitivity is 10 times larger than its predecessors, such as GafChromic MD- 55-2 and HS. The useful dose range is from 1 to 800 cGy, and presents two absorption peaks at 636 and 585nm [9], [10] its response is energy independent, and according to the

manufacturer specifications, it has a real time response [11].



(a)



(b)

Fig. 2 Transverse views at isocenter level for anthropomorphic phantom showing dose distributions for conventional radiotherapy (a) and (b) isodose curves are shown for film as calculated using the calibration film set for density to dose conversion by MATLAB software.

#### VI. RESULT

One aim of good radiotherapeutic practice is to achieve homogeneity of dose throughout the treatment volume. The recommendation of the ICRU report No. 50 is to achieve radiation dose homogeneity throughout a planning target volume (PTV) of between -5 and +7% of the prescribed dose [10].

At the tissue-air interface, the average measured percentage dose (% dose<sub>m</sub>) is about (106.3 $\pm$  3.9)% with TLD data, and

(101.2 ± 4.3)% with radiochromic film data. Similarly, in the central part of the cavity, the % dose is (98.2 ± 2.9)% with TLD data, and (91.7 ± 5.0)% with radiochromic film data. Using the CT-based generated dose distribution (without inhomogeneity correction), the average calculated percentage dose (% dose) is (98.7 ± 1.0)% at the tissue-air interface and 98% in the central part of the air cavity.

The three centers were asked to simulate, plan and treat (with a prescription of 100 cGy) the patient according to their standard practice. Point doses from resultant computer plans were calculated for each TLD position. Measured and calculated (planning computer) doses were compared.

The results, as evaluated maps, were then compared with the original fluence maps, as reference maps. All of the current work procedures were performed using in-house codes written by MATLAB.

## VII. CONCLUSION

The original fluence maps were manipulated for several translational and rotational displacements. The results, as evaluated maps, were then compared with the original fluence maps, as reference maps. All of the current work procedures were performed using in-house codes written by MATLAB. Agreement between Cord absorbed dose calculated by ISOGRAY and TLD & Film Dosimeter measurements was within 3% for 95% of all measurement points. ISOGRAY does model relative increases/decreases in Cord absorbed dose due to different plans reasonably well, so IMRT optimization can be expected to be successful in reducing Cord absorbed dose. However, the use of an absolute goal for Cord absorbed dose should be considered with caution. For the beam energies studied, the variation from the % dose at the tissue-air interface for a given dosimetry technique is relatively small [ $< 7\%$  (TLD), and  $< 5\%$  (radiochromic)] and therefore should not be significant in clinical settings. The variation from the % dose at the tissue-air interface is more significant for lower energies 6.2% for 6 MV.

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