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THE PROBABILITY OF COMPLICATIONS OF THE OAR OF THE HEAD-AND-NECK WITH SIMULTANEOUS INTEGRATED BOOST AND SEQUENTIAL INTENSITY-MODULATED RADIOTHERAPY TECHNIQUES

Introduction

Head and neck cancer belongs to the most prevalent cancers, and are the sixth leading cause of cancer worldwide. Head and neck squamous cell carcinomas (HNSCCs) develop in the mucosal linings of the upper aerodigestive tract(1). Radiotherapy is an important treatment modality in head and neck cancer. In recent years new radiotherapy techniques have been developed.The IMRT technique is characterized by a highly conformal dose distribution to targets, whereas a constraint dose to organs at risk (OARs)(2). Sequential boost (SEQ) intensity-modulated radiation therapy regimens for HNC are composed of elective irradiation followed by a series of reduced boost fields aiming at the different overall doses needed for tumor control or OARs tolerance. Simultaneous integrated boost (SIB) technique gained popularity as it improved planning efficiency and escalated the dose per fraction delivered to the gross target volume (GTV) to potentially enhance tumor control(3). SIB-IMRT is a safe and effective treatment for HNC, whereas it offers the following advantages: shortening of the treatment time and increased

biologically equivalent dose (BED) to the tumor with dose per fraction slightly >2 Gy(4).

Patients and methods

Patient selection and contouring

Ten patients with HNSCC (stages T1NM-T4aN3M0) were randomly selected from a list of patients previously treated with VMAT plan (Monaco planning system, Elekta Synergy) using 6-MV photons in the Radiotherapy Department at Tomsk Regional Oncology Center. All patients were simulated (CT scaner with 3mm slice thickness) and treated supine, immobilized by a thermoplastic head and shoulder mask. Treatment was given in 5 daily fractions per week. Seven patients with Stage III-IVB disease treated with concurrent chemoradiation (cisplatin 100mg/m² every 3weeks).

The high-risk target volume TV consisted of the gross tumor volume (GTV)and a 10-mm margin surrounding GTV, which are equal to the clinical target volume (CTV), CTV1. CTV2 consisted of elective nodal regions at risk. Expanding the CTVs by an isotropic margin of 5 mm gave the corresponding PTVs. OAR were delinaded such as: parotid gland, mandible, esophagus, spinal cord, brainstem, cochlea, thyroid gland and submandibular gland.

Prescription radiotherapy

The linear-quadratic model with a/b values (e.g.10 Gy for tumor; 2 Gy for spinal cord(SC);2 Gy for brain stem(BS)) was employed to calculate biologically effective doses. SEQ dose prescription for all datasets was 25 single fractions of 2 Gy for TD (total dose) 50 Gy to PTV2 followed by 10 single fractions of 2 Gy for TD 70 Gy to PTV1, a total time of treatment 7weeks.SIB dose consisted of 25 daily single fractions of 2 and 2.8 Gy to PTV 2 and PTV 1 respectively, resulting in TDS of 50, 70 Gy and a total time of treatment 5 weeks.

Physical plan evaluation

Quantitative comparisons used a DVH analysis, with parallel qualitative visual comparisons of the axial isodose curves. The mean volumes of PTV1–2, the Dmean, Dmax (maximal dose to the PTV), D2 (dose delivered to at most 2 % of the PTV), D100 (dose delivered to 100 % of the PTV), D98 (dose delivered to 98 % of the PTV) and D95 (dose delivered to 95 % of the PTV) for PTV1–2 were also evaluated. Regarding OARs the Dmax for the spinal cord, brain stem.

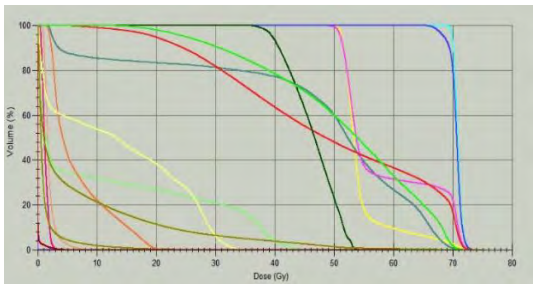

Fig. 1. SIB

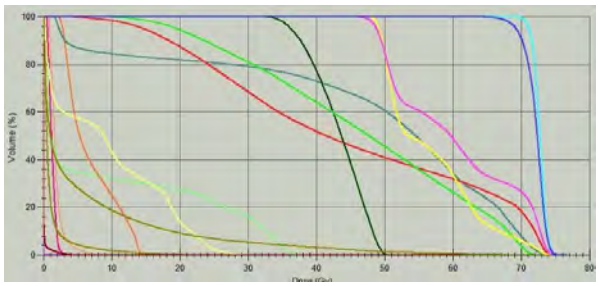

Fig. 2. SEQ

Biological Plan Evaluation

BED: The concept of biologically effective dose (BED) is commonly used for iso-effective dose fractionation calculation. It is derived from the LQ model and

is defined as:

$$BED = nd\left[1 + \frac{d}{\alpha / \beta}\right] \quad (1)$$

The BED calculations were performed using an equation written in an excel sheet. Each dose was converted to the corresponding BED using equation (1) and taking into account the number of fractions and the different α/β values for tumors and OARs. For all OARs, e.g brain stem and spinal cord α/β = 2 Gy was used in all plans. For PTV1 and PTV2 in SEQ and SIB plans, α/β = 10 Gy were used to calculate the BED (BED10)

Statistical analysis

Microsoft Excel 2010 and IBM SPSS Version 20 were used for calculations and for descriptive statistics. Descriptive statistics of the data are presented as mean ±standard deviation (SD). The differences in the mean between the two schemes were compared and analyzed using the Wilcoxon ranked sign test. Statistically significant differences were assumed for a significance level of $p < 0.05$.

Results

Both techniques achieved the planning objectives in tumor coverage 95 % of tumor volume received ≥ 95%of the dose, Dmax not more than 107 % of the dose(not >2% of PTV).Also, Both techniques also respected the planning objective of Dmax < 45 Gy,<50 Gy (limit)[1 cc of the PTV cannot exceed 50 Gy] for the spinal cord and Dmax < 54 Gy, <60 Gy (limit) [1 cc of the PTV cannot exceed 60 Gy] for brain stem.

The results are summarized in Table 1

Table 1

Dose-volume histogram parameters and treatment efficiency for SeqB and SIB plans (mean ± SD)

		SIB	SEQ	P-value
PTV70	Reference dose	70	70	
	Volume	157.3±104.1	157.3±104.1	
	D mean	71.9±0.7	72.6±0.3	0.002
	BED	92.52±1.07	87.58±0.4	0.002
PTV50	Reference dose	50	50	
	Volume	427.8±121.8	427.75±121.8	
	D mean	61.11±2.95	62.9±3.2	0.006
	BED	75.97±4.38	78.7±4.8	0.006
Spinal cord	Dmax	39.6±3.7	40.8±5.6	0.14
	BED	70.33±9.3	64.97±11.5	0.1
Brain stem	Dmax	31.1±17.3	30.5±17.6	0.25
	BED	55.7±36.1	47.8±32.2	0.12

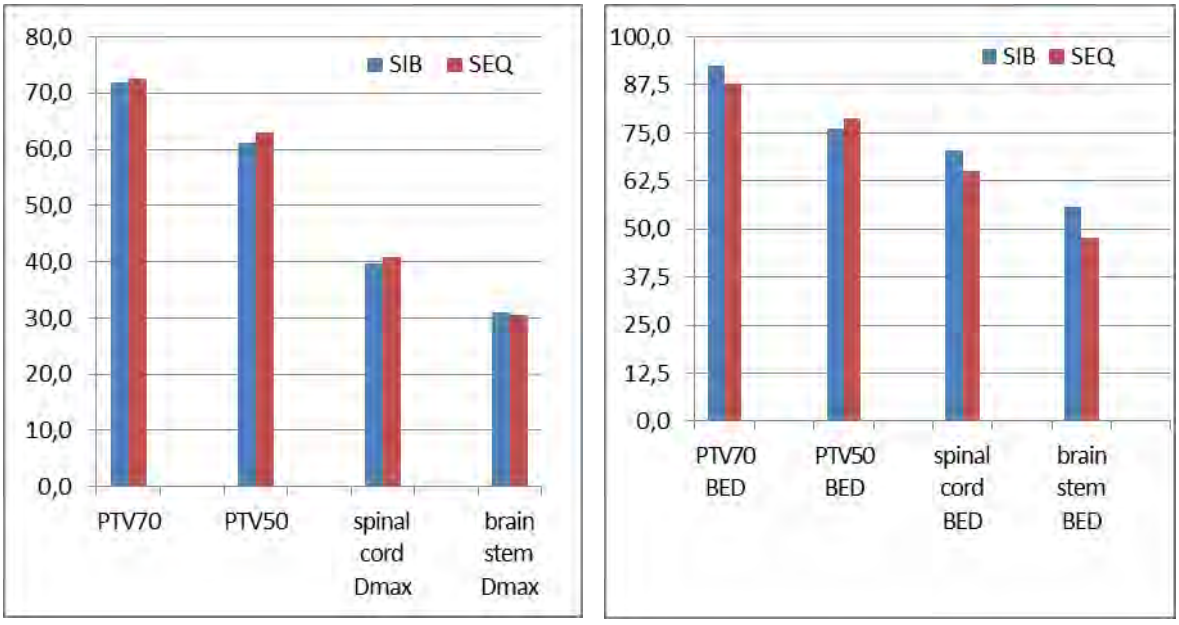

Fig. 3. right figure compare between both techniques SIB and SEQ regarding physical dose and left figure regarding BED.

Discussion

Both VMAT techniques can reach equal dose coverage of PTV, as in our study both techniques achieved equal dose coverage of PTV. The BED reflects the radiobiological effectiveness of the physical dose (PD) delivered with a unique fractionation scheme(5). There are four major factors of BED that provide the capability of quantitatively estimating the biological re-

sponse to the delivered dose: (1) cellular radio-sensitivity; (2) treatment dose-per-fraction (DPF); (3) total delivered dose; and (4) overall treatment time(OTT).the most significant change associated with the SIB technique compared to the SEQ approach is two parameters: (1) the shortening of the OTT; and (2) the increase of FS to the boost volume. High tumor control probabilities (TCPs) are associated with large BEDs, which are a result of a small number of large dose fractions. Increasing BED in HNC for local tumor control can lead to significant clinical benefits, which is associated with improved survival(4).In our study, the BED to PTV-70 was higher in SIB than SEQ which leads to increase tumor control probability in the SIB technique.our study showed a slight difference in the mean dose of Dmax to the spinal cord and brain stem in both techniques. However, BEDs were higher for the spinal cord and brain stem in SIB due to high dose per fraction and reduction in overall treatment time which increase the risk of myelopathy.From a socioeconomic prospective, fewer treatment fractions also lead to time and cost savings as well as reducing the workload of health care providers.

Conclusion

The SIB technique is a more effective way of planning and delivering VMAT, because it involves the use of the same plan for the entire course of treatment, the ability for dose/fraction escalation to a tumor, conformal avoidance of normal tissues and higher biologically-effective tumor dose and/or lower biologically-effective dose normal tissues outside the tumor volume. SIB may be superior to SEQ in its convenience and short-course of treatment. However, there is an increased risk of complication due to the high dose per fraction and reduction in overall treatment time which leads to increase BED for SC and BS so the risk of complications are increased such as myelopathy.

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INVESTIGATION AND COMPARISON OF GAMMA BACKROUND AROUND TOMSK POLYTECHNIC UNIVERSITY (TPU) BUILDING

Abstract

There is now due consideration of the effect of buildings on the comfort and health of the population but not on radiation exposure. Buildings can raise the background radiation close to its position as sources of radiation and a significant increase in gamma history is expected. Gamma background can be predicted to increase significantly. Such issues are still not included in publications. A gamma background analysis around TPU buildings has been undertaken in this regard. Gamma levels were measured and analyzed using gamma-ray detector. Around the building, the measurements were made from the center of the building 10 cm and 1 m from the wall with 2-5 m variable pitch. A total of 9-10 different points were chosen for each measurement location. Comparison between the measuring locations were made. The study revealed a number of correlations, which indicated that the background radiation behind the TPU buildings increases significantly.