QUALITATIVE ANALYSIS OF HEAD AND NECK TREATMENT PLANS FOR INTENSITY MODULATED RADIATION THERAPY

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Introduction

According to the World Health Organization (WHO) over the world yearly every sixth person dies from the oncological disease. According to the Lithuanian Register data last year 846 new cases of head and neck tumors were registered, of which 663 deaths were reported.

External beam radiotherapy using high energy photon beams are mostly used for the head and neck cancer irradiation. Even it is used such modern radiotherapy technologies, like intensity modulated radiotherapy (IMRT), which allows to irradiate tumor with a higher dose per treatment, at the same time reducing exposure to the critical organs, avoiding acute reactions, like dry mouth, swallowing problems, and etc. Therefore, still the main challenge of external beam radiotherapy for head and neck cancer is to protect irradiation of organs at risk, within limits of the tolerance dose level, determining the possible risks of early and late reactions.

The aim

The aim of this study was to create a fast and simple qualitative analysis of head and neck IMRT treatment plans, determining the possible risks of early and late reactions, assuring local tumor control, and so defining the outcome of radiotherapy procedure.

Materials and methods.

Qualitative analysis was done for 20 randomly chosen plans.
Two different “protocols” were used for qualitative analysis of IMRT plans: QUANTEC (Quantitative Analysis of Normal Tissue Effects in the Clinic) guidelines [1] and ONTARIO Head and Neck IMRT protocol [2].

Table 1. Tolerance dose levels for two different “protocols”: QUANTEC and ONTARIO.

Organ	Dose parameter	QUANTEC Dose, Gy	ONTARIO Dose, Gy
Brain	D_{max}	60	60
Brain stem	D_{max}	54	54
Optic chiasm	D_{max}	55	50
Spinal cord	D_{max}	50	48
Cochlea	D_{mean}	45	50
Parotid	D_{mean}	25	26
Pharynx	D_{mean}	50	-
Larynx	D_{max}	66	45
Oesophagus	D_{mean}	34	45
Planning tumor volume (PTV) constraints			
PTV/ “target”		95 – 107 %	95 – 115 %

1. Bentzen, S.M., et al., Quantitative Analyses of Normal Tissue Effects in the Clinic (QUANTEC): an introduction to the scientific issues. Int J Radiat Oncol Biol Phys, 2010. 76 (3 Suppl): p. 3-9.
2. Recommendation Report Dose Objectives for Head and Neck IMRT Treatment Planning A project developed by the Head and Neck Community of Practice of the Radiation Treatment Program of Cancer Care Ontario for circulation to Regional Cancer Programs 2014-02-01

Materials and methods.

Tolerance dose levels, according to QUANTEC and ONTARIO guidelines, for the most treatment cases delineated critical organs (spinal cord, parotid glands, and oesophagus) were "recalculated" to the "points", which are presented in Table 2. Such kind (using "points' scale") of the IMRT plans evaluation using ONTARIO protocol was introduced in the 2017 Radiation Knowledge Competition for Head and Neck Nasopharynx case [1].

Table 2. Tolerance dose levels of organs at risk/ critical organs relation to the points.

Organ	Lower dose limit, Gy			Upper dose limit, Gy		
	1*	2*	Points	1*	2*	Points
Spinal cord, D_{max}	≤48	≤46	3	≥50	≥48	0
Parotid gland, D_{mean}	≤20	≤20	2	≥25	≥26	0
Oesophagus, D_{mean}	≤30	≤40	3	≥34	≥45	0
Planning tumor volume (PTV) constraints						
PTV*	≤ 92 %		0	≥ 95 %		5
1* – QUANTEC, 2* – Ontario H&N IMRT Protocol						

1. https://radiationknowledge.org/competition2017/

Materials and methods.

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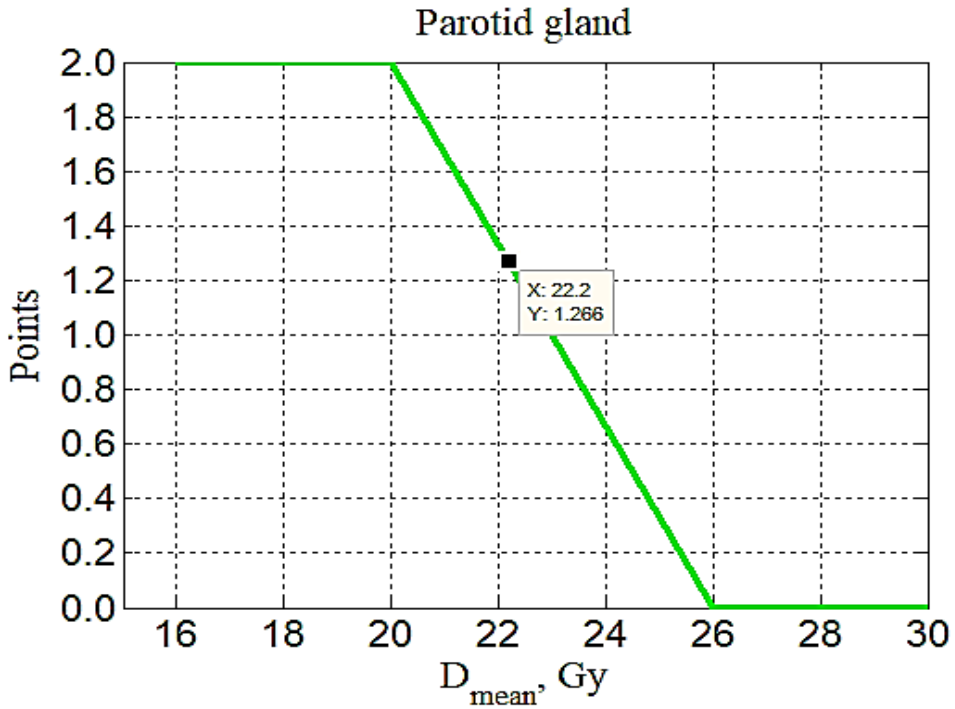


Fig. 1. The "points' scale" usage for the parotid gland: planned parotid gland mean dose per whole treatment for one of the IMRT plans were 22.2 Gy, what corresponds to 1.27 points, following ONTARIO guidelines.

Materials and methods.

For the faster evaluation and prediction of possible early and late reactions for the treated patients were created the program “IMRT Plans Analysis” (figure 2).

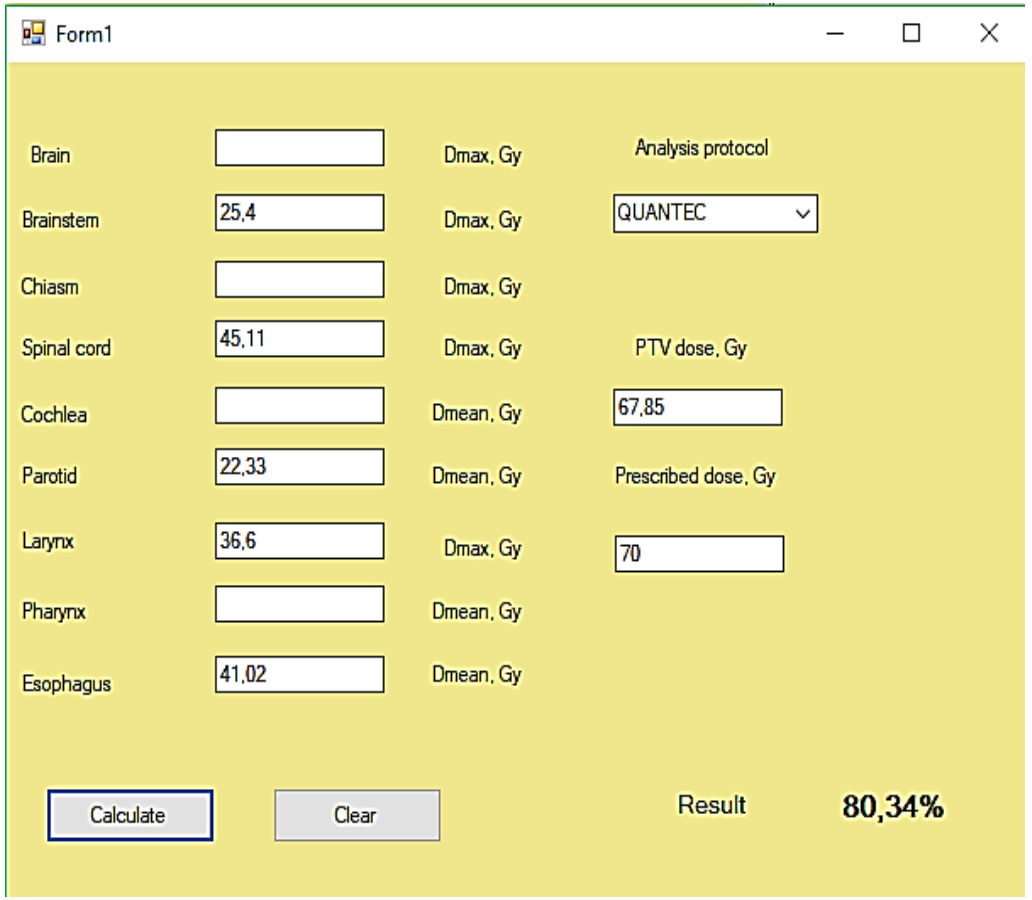


Fig. 2. The main window of the program “IMRT Plans Analysis”.

Results.

- These results confirmed clinically registered dysphagia, and even parotid glands function reduction up to 25 % and/or esophagitis risk for 38 % patients‘, like it was observed following to QUANTEC recommendations.
- Also this investigation showed, that due to QUANTEC and ONTARIO guidelines, even if the risk of early and late reactions are possible to reduce, however to avoid a higher irradiation of some critical organs, like parotid glands and oesophagus is impossible.

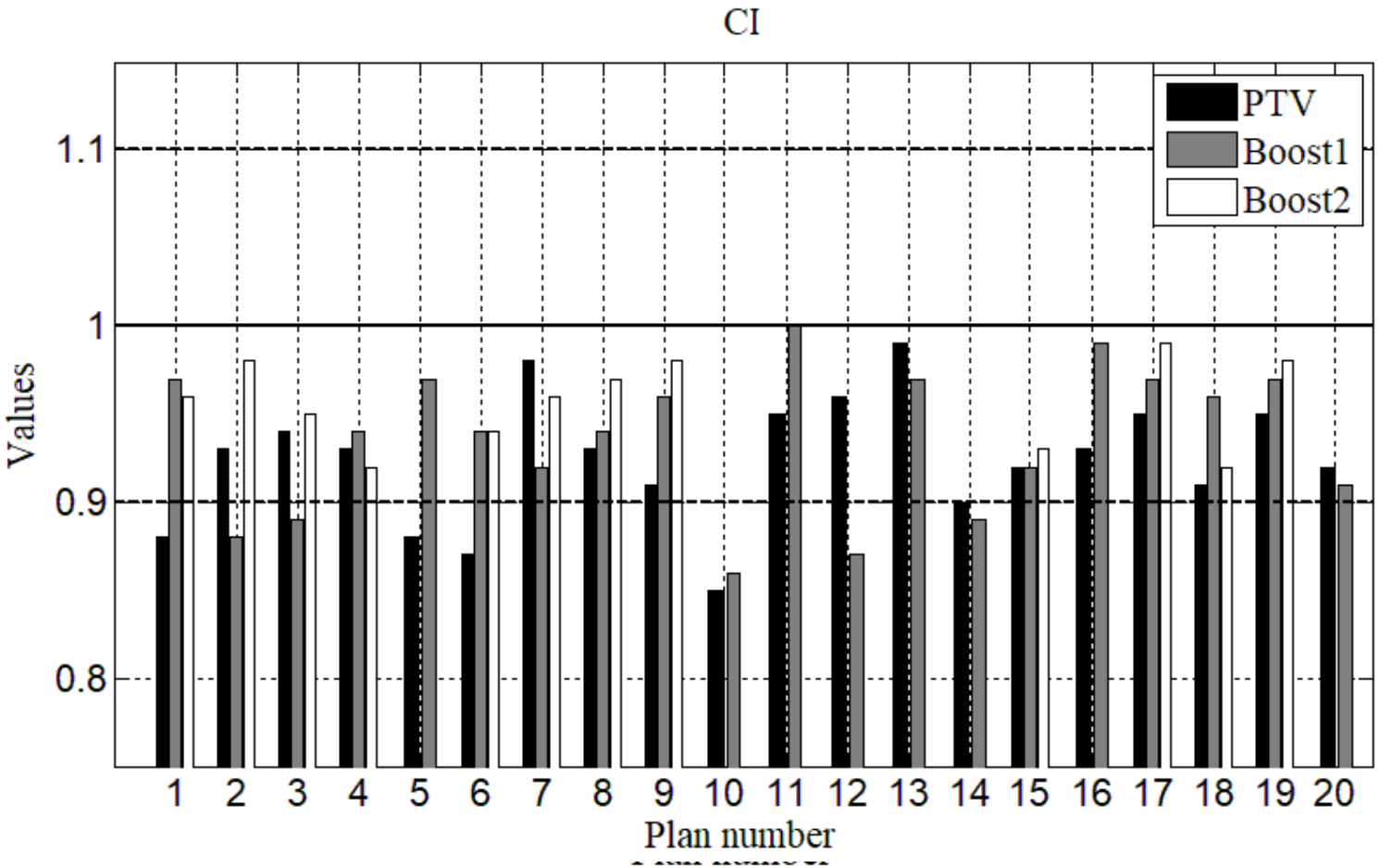
Results.

For the qualitative analysis of the treatment plans were also used planning tumour volume evaluation, using homogeneity (HI) and conformity (CI) indices, which usually shows the uniformity of dose distribution in the irradiated target volume.

$$HI = \frac{D_{max}}{D_p} \quad (1)$$

$$CI = \frac{V_{95}}{V_{PTV}} \quad (2)$$

where D_{max} is the maximum dose; D_p is the prescribed dose; V_{95} is the PTV volume covered by 95 % isodose; V_{PTV} – total volume of PTV.



Conclusions

- Following to the QUANTEC and ONTARIO guidelines, even if, the risk of early and late reactions is possible to reduce, to avoid a higher irradiation of some critical organs, like parotid glands and oesophagus is impossible, due to irradiated volume and critical structures regions intersection. According to this, for some of the patients were observed such late reactions, like xerostomia, dysphagia and even parotid glands function reduction up to 25 %.
- Using “points’ scale” evaluation, were noticed, if the plans percentage value is more than 65 %, the possibility to observe early and late reactions of evaluated plans significantly decreases.
- Analysis of homogeneity and conformity indices were in a close proximity to the 1, what showed a sufficient and assured local control of the tumour.

Thank You for Your attention !