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Dosimetric influence of pitch for radiotherapy of long treatment volumes

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Purpose/Objective: Pitch usually has little impact on the dose distribution for radiation of small spherical treatment volumes such as brain metastases or prostates. However, for geometrical reasons a pitch might be detrimental for patients with long treatment volumes, such as nasopharyngeal carcinoma (NPC) or esophageal cancer. During the course of radiotherapy patients with head and neck cancer may have rotational variations of up to 8° and esophageal cancer patients of up to 6° (Zhang L et al. Int J Radiat Oncol Biol Phys 2006, Chen YL et al. Int J Radiat Oncol Biol Phys 2007). The purpose of our study was to investigate if the dose distribution in the case of long treatment volumes is relevantly affected by the patient's pitch and if a correction using a treatment couch with six degrees of freedom (6DoF) is necessary.

Materials and Methods: 10 patients with NPC and 10 patients with esophageal cancer have been included in our planning study. All patients have been treated with volumetric modulated arc therapy (VMAT) with 66-70 Gy in 33-35 fractions in the case of NPC and with 41.4-54 Gy in 23-28 fractions in the case of esophageal cancer. Patient's pitch was simulated by tilting the planning CT in ventral and dorsal direction by +/-1.5° and +/-3° around the middle of the dens axis for NPC volumes and the middle of the PTV for esophageal volumes. These rotational values were chosen, because most clinical treatment tables with 6 DoF are not able to adjust a tilt of more than 3°. A copy of the original CT dataset was made, identifying DICOM tags were deleted and PTV structures and structures of OARs were copied on the CT dataset. Verification plans were calculated on the four tilted datasets. PTV coverage and mean and maximum dose to the organs at risk (OARs) were compared to the original plan and to the dose constraints of the OARs.

Results: For NPC patients the deviation in dose to the PTV is increasing with the degree of pitch but the effect appears to be relatively small with mean changes of up to 2%. For esophageal cancer pitches of 1.5° and 3° resulted in even less variation of dose to the PTV and PTV coverage with mean changes of up to 1%. The OARs that are most affected by a certain tilt of NPC patients are brainstem, spinal cord, lenses, oral mucosa and parotid glands (see Table 1). Brain, chiasm and optical nerves were stable in absolute dose. For esophageal cancer there was no significant change in dose to any OAR and none of the OARs exceeded the organ tolerance due to the pitch. However, in NPC patients 11/40 treatment plans would no longer be acceptable according to the dose constraints of the OARs with a pitch of +/-1.5° (N=1/N=2) and +/-3° (N=3/N=5).

Table 1: Dose deviations for organs at risk in nasopharyngeal carcinoma patients dependent on degree and direction of the patient pitch. Standard deviations are shown in brackets.

	Pitch Nasopharyngeal Carcinoma [%]			
	3° ventral	1.5° ventral	1.5° dorsal	3° dorsal
Chiasm max	n.s.	n.s.	n.s.	n.s.
Chiasm mean	n.s.	n.s.	n.s.	n.s.
Brain mean	n.s.	n.s.	n.s.	n.s.
Brainstem max	-3.7 (3.3); p=0.013	-1.7 (1.9) 0.037	2.9 (3.1) 0.022	6.0 (6.3); p=0.017
Brainstem mean	-2.4 (4.0); p=0.028	n.s.	1.3 (2.3) 0.047	3.0 (5.5); p=0.037
Lens max (i)	3.3 (3.0); p=0.028	2.5 (2.5) 0.017	n.s.	-2.3 (2.9); p=0.037
Lens max (c)	3.2 (3.3); p=0.037	n.s.	n.s.	n.s.
Spinal cord max	-3.9 (5.2); p=0.028	-2.2 (3.0); p=0.047	5.1 (4.2); p=0.017	10.0 (9.9); p=0.013
Spinal cord mean	n.s.	-0.6 (0.6); p=0.013	1.9 (3.5); p=0.013	3.1 (4.1); p=0.013
Oral mucosa mean	2.6 (2.5); p=0.022	n.s.	-1.6 (1.3); p=0.013	-2.8 (3.0); p=0.017
Parotid gland mean (i)	4.3 (4.3); p=0.017	2.0 (2.2); p=0.022	-1.0 (1.6); p=0.047	-3.0 (3.1); p=0.014
Parotid gland mean (c)	4.1 (3.8); p=0.007	1.8 (1.7); p=0.013	-2.3 (2.1); p=0.009	-3.1 (3.2); p=0.013
Optical nerve max (i)	n.s.	n.s.	n.s.	n.s.
Optical nerve max (c)	n.s.	n.s.	-3.5 (3.8); p=0.047	n.s.

i: ipsilateral, c: contralateral, n.s.: not significant

Conclusions: PTV coverage in both tumor entities was only slightly affected, but pitch error could be detrimental for OARs in NPC patients. Therefore a correction is recommended for NPC patients, even with a pitch mismatch of 1.5°. In the latter situation the use of a 6DoF table might be clinically relevant.

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Rectal tumor volume shrinkage evaluated with MRI during preoperative chemoradiotherapy

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Purpose/Objective: Neoadjuvant chemoradiotherapy (CRT) decreases the local recurrence rate in patients with locally advanced rectal cancer. To enhance response, multiple centers are investigating the possibility of a boost dose to the gross tumor volume (GTV), either sequentially or simultaneously. Few data is available on GTV regression during CRT. We aim to determine the pattern in order to optimize timing of dose escalation on the GTV and assess possibilities for adaptive planning.

Materials and Methods: MRI was obtained before, weekly during, and 4 and 7 weeks after a five-week course of concomitant CRT in seven patients with locally advanced rectal cancer (T3-4 and/or N1-2). A dose of 50 Gy was administered during CRT, combined with daily capecitabine. GTV was contoured on high resolution axial T2 images, aided by diffusion weighted imaging (DWI) and the apparent diffusion coefficient map (ADC). Planning target volumes (PTV) were created on each time point, with margins based on previous research: 10 mm anteroposteriorly, 6 mm laterally and 12 mm craniocaudally.

Results: On the whole, 52 usable MRIs were acquired. GTV volume measured 63.3 cc (SD 20.5 cc) at baseline and PTV 209 cc (SD 50 cc). In six patients, tumor shrinkage started in the first two weeks of CRT, amounting to an average reduction of 10% per week (fig. 1). The seventh patient showed no response during CRT and suffered local progression before planned surgery.

Overall, mean GTV volume after CRT was 32.3 cc (± 9.3 cc), a reduction of 45.7 % (± 17.7 %, p=0.018). The PTV volume after CRT was reduced by 72 cc ± 31 cc (34 % ± 12 %, p=0.018). Further reduction occurred up to seven weeks post-CRT, resulting in mean GTV volume of 22.3 cc (± 9.3 cc), showing a total reduction of 58.3% (± 30.0%, p=0.028) compared to baseline.