Evaluation of robustness of posterior-beam-weighted proton treatment planning for oropharyngeal cancer.

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Introduction

- Patients undergoing concurrent chemoradiation therapy (CCRT) for oropharyngeal cancer (OPC) frequently experience tumor regression or weight loss during treatment, which can result in dose delivery degradation such as critical increase on dose to organ-at-risk (OAR) and decrease on dose to target volume.
- This may require the patient repeat CT simulation to assess the dose change, and then estimate the necessity of adaptive re-planning. When it comes to making decision whether re-planning is required, the robustness of treatment plan against these anatomical change must be considered, because it mitigates risks of dosimetric change on target volume as far as robustness ensures, eventually reducing labor-intensive efforts for re-planning.
- In this study we present proton treatment planning of OPC which maximize robustness by varying beam weighting in the same beam configuration, observing dosimetric change on OAR we concern.

Materials / Method

- The current dose prescription for OPC in Samsung Medical Center:
 - GTV: 2.4 Gy x 18 fx. (TOMO) + 2.4 Gy x 10 fx. (Proton)
 - CTV: 2.0 Gy x 18 fx. (TOMO) + 2.0 Gy x 10 fx. (Proton)
- Two beams (RAO and LPO) were used for OPC proton planning (Fig. 1), and three plans were made varying beam weighting ratio, RAO/LPO from 1, 2 to 3.

Fig. 1 3D view of beam configuration (left) and dose distribution (right)

- Each plan was recalculated using a weekly-control-CT which shows substantial alteration in body contour due to weight loss. (Fig. 2)

Fig. 2 Comparison of planning CT and control CT

- Three plans according to beam weighting ratio were recalculated on control CT. Target dose coverage was analyzed on each plan and each beam. And dose change on OARs such as parotid gland, brainstem and spinal cord were also analyzed.

Results

Table. 1 Dose statistics of original plan on planning CT

Beam weighting (RAO:LPO)		GTV D _{98%} (2400 cGy)	CTV D _{98%} (2000 cGy)
1:1 (GTV 1200:1200 / CTV 1000:1000)	Sum	2415 (100.6% of 2400 cGy)	2008 (100.4% of 2000 cGy)
	RAO	1200 (100.0% of 1200 cGy)	993 (99.3% of 1000 cGy)
	LPO	1202 (100.2% of 1200 cGy)	1000 (100.0% of 1000 cGy)
1:2 (GTV 800:1600 / CTV 667:1333)	SUM	2405 (100.2% of 2400 cGy)	2001 (100.1% of 2000 cGy)
	RAO	798 (99.8% of 800 cGy)	660 (99.0% of 667 cGy)
	LPO	1595 (99.7% of 1600 cGy)	1328 (99.6% of 1333 cGy)
1:3 (GTV 600:1800 / CTV 500:1500)	SUM	2406 (100.3% of 2400 cGy)	2001 (100.1% of 2000 cGy)
	RAO	597 (99.5% of 600 cGy)	495 (99.0% of 500 cGy)
	LPO	1799 (99.9% of 1800 cGy)	1495 (99.7% of 1500 cGy)

Table. 2 Dose statistics of recalculated plan on control CT

Beam weighting (RAO:LPO)		GTV D _{98%} (2400 cGy)	CTV D _{98%} (2000 cGy)
1:1 (GTV 1200:1200 / CTV 1000:1000)	Sum	2397 (99.9% of 2400 cGy)	1969 (98.5% of 2000 cGy)
	RAO	1198 (99.8% of 1200 cGy)	968 (96.8% of 1000 cGy)
	LPO	1184 (98.7% of 1200 cGy)	985 (98.5% of 1000 cGy)
1:2 (GTV 800:1600 / CTV 667:1333)	SUM	2379 (99.1% of 2400 cGy)	1964 (98.2% of 2000 cGy)
	RAO	796 (99.5% of 800 cGy)	642 (96.3% of 667 cGy)
	LPO	1572 (98.3% of 1600 cGy)	1307 (98.0% of 1333 cGy)
1:3 (GTV 600:1800 / CTV 500:1500)	SUM	2383 (99.3% of 2400 cGy)	1971 (100.1% of 2000 cGy)
	RAO	597 (99.5% of 600 cGy)	480 (96.0% of 500 cGy)
	LPO	1776 (98.7% of 1800 cGy)	1476 (98.4% of 1500 cGy)

Table3. Dose statistics of OAR of original plan and recalculated plan

		Spinal Cord (max.)	Brainstem (max.)	Rt. Parotid gland (avg.)
Original plan	1:1	887	818	715
	1:2	1180	1090	669
	1:3	1330	1224	650
Recalculated plan	1:1	893	817	745
	1:2	118	1088	731
	1:3	1332	1226	725

Discussion

- As table 1 and 2 shows, three plans which are made according to beam weighting ratio were all sufficient to avoid under-coverage of both target volume (GTV and CTV) in recalculated plan on control CT.
- In table 2, nevertheless, D_{98%} of RAO beam of CTV shows coverage under 97% of beam's prescription dose, whereas LPO beam shows coverage over 98%. Therefore, reducing dose weight on RAO beam and increasing one on posterior beam are considered to bring better robustness against anatomical change.
- Unfortunately, increasing beam weight on posterior beam causes more dose on OAR such as spinal cord and brainstem. Even though parotid gland shows reduced dose, its difference is only within 1 Gy. Also, when it was recalculated on control CT, that difference get inconsiderably less.
- In conclusion, posterior beam weighted proton treatment planning shows definite improvement on robustness against anatomical change, while a proper weighting ratio needs to be dealt with considering OAR dose and patient's physical condition.