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Short Commentary

Using Stereotactic Radiation Systems to Irradiate and Re-Irradiate Head and Neck Cancers

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Background

Head and neck cancers are challenging to treat with conventional radiation therapy. There are many critical structures that include optic chiasm, optic nerves, cochlea, eyes, temporal lobes, brain stem, spinal cord, parotid glands, mandible, esophagus and larynx [1]. Among the head and neck cancers, nasopharyngeal cancers, skull base cancers, and recurrent head and neck cancers are the most challenging to irradiate. Recent advance in Intensity Modulated Radiation Therapy (IMRT) has allowed treating head and neck cancers and spare these critical structures without compromising the tumor control [1]. Stereotactic radiation systems have been used to boost the tumor to further improve the outcome [2]. This paper, a part of series of commentaries on stereotactic radiation treatment systems [3] use on selected challenging clinical situations, discusses the use of a robotic stereotactic machine as an example in boosting head and neck cancers and also for treating recurrent head and neck cancers [2,4].

Stereotaxy of CyberKnife

CyberKnife (Accuray Inc., Sunnyvale, CA) robotic stereotactic radiation system [5] uses skull tracking, Xsight spine tracking, Xsight lung tracking for peripheral lesions, implanted fiducial tracking, and Synchrony real-time tracking system. With the many degrees of freedom of the robotic arm, it could deliver very high dose accurately with active tracking. Other advanced systems may also have similar capacities [6-8]. The CyberKnife system uses robotic arm to go through a large number of nodes (positions) to optimize the dose distribution. To limit damage to the surrounding critical normal tissues, the treatment margins could be optimized. The accuracy of CyberKnife has been found to be < 1mm [9].

Treatment planning for stereotactic radiation and re-irradiation

The definition of the salvage target volumes are different from those used in the initial treatment, usually the margins are tighter. PET scan may be useful in defining the gross tumor volume (GTV) and clinical target volume(CTV) [10]. For example, the CyberKnife treatment planning computer system allows multi-modal image registration including CT to MRI and CT to PET image registration. This would allow more accurate target delineation. PET and MRI may also be useful in planning initial radiation treatment.

Discussion

The outcome and toxicity are generally better in irradiation of head and neck cancers with more advanced stereotactic machines [11,12]. For example, in boosting nasopharyngeal cancers, the tolerance of the optic apparatus, brain stem and temporal lobes are usually reached at about 70 Gy in 2 Gy fractions [1]. Conventional radiotherapy is limited by these dose constraints. Stereotactic radiosurgery (SRS) has been used to boost the nasopharyngeal primary of a median dose of 66 Gy with another median dose of 12 Gy SRS (EQD2 [13] of 22 Gy) to a total equivalent dose of 78 Gy using frame based LINAC. There was no complication related to the added SRS boost [2].

Not surprisingly, stereotactic radiation treatment systems have been known to be useful in treating challenging cases in head and neck cancers [6-8]. For example, CyberKnife has become well recognized to be useful in radiation re-treatment of recurrent head and neck cancers because of its robotic stereotaxy. The results of CyberKnife re-treatment are encouraging in both salvage rates and toxicity rates. CyberKnife's robotic stereotactic system could also be used for image guidance for precise radiation delivery in conventional fractionations when the tumor is large, close to critical structures or in re-irradiation [11].

Selecting patients with recurrent head and neck cancers for re-irradiation may need to consider cancer control elsewhere, expected life expectancy, the proximity and condition of the critical structures, and time to radiation [1, 14].The normal tissue tolerance may be different than that of initial course of radiotherapy [15-17]. To find the combined effects of different doses and fractions between the initial radiotherapy and re-irradiation, Biologic Effective Dose (BED) and Biologic Equivalent Dose at 2 Gy per fraction (EQD2) [13] may be calculated, and the dosimetric guidelines may be applied. However, tumor control and normal tissue tolerance data based on actual re-irradiation clinical experience are scant [6,15,18,19]. The advantages of hypofractionated stereotactic body radiation therapy (SBRT, usually means 1-5 fractions) are that it is more effective and convenient for palliating symptoms. It has been postulated the large fractions of SRS and SBRT may overcome the radiation resistance of recurrent nasopharyngeal cancers [12].

A hypothetical case for clinical decision making discussion

Suppose a healthy 40 years old Asian man presented with a recurrent 2cm nasopharyngeal carcinoma and bilateral lymph nodes. He was treated with a course of chemoradiation to 70 Gy in 2 Gy fractions for a stage III nasopharyngeal carcinoma. Should this patient be re-treated in this hypothetical case?

The prognostic value of performance status has consistently been found to be important in selecting which patients will benefit from re-irradiation [15,20], this patient would have a high probability of benefitting from the re-irradiation. For rT1-T2 nasopharyngeal cancers, SRS of 12. 5 Gy (BED of about 28 Gy) has been found to be quite effective and safe (12). Larger doses have been used when the tolerance for risk of serious normal tissue complication is higher e.g. for this young healthy patient [12]. Unlike initial treatment, there are no well accepted dosimetric guidelines for normal tissue tolerance in re-irradiation [15]. However, the Quantec guidelines [17] and Task Group 101 report [16] may be useful in helping to select the optimal dose for the treatment. A list of the Biologic Equivalent Dose at 2 Gy (EQD2) [13] could be calculated for each of these critical organs, the tolerance of these structures could be estimated in the literature [15,19]. The tolerance dose levels could then be adjusted according to the toxicity tolerance based on the performance status and desire of the patient. For example, a 5-10% may be acceptable to some patients in the re-irradiation setting as opposed to the 0-5% risk in the initial treatment setting.

Stereotactic radiation systems may provide excellent capacity for irradiating and re-irradiating challenging head and neck cancers [6-8].

References

1. Cox JD, Ang KK. Radiation Oncology: Rationale, Technique, Results, 9th Edition. 2009.

2. Chang SD, Tate DJ, Goffinet DR, Martin DP, Adler JR, Jr. Treatment of nasopharyngeal carcinoma: stereotactic radiosurgical boost following fractionated radiotherapy. Stereotact Funct Neurosurg. 1999, 73(1-4): 64-67.

3. Cheung R. Using a Robotic Stereotactic Radiation Treatment System to Treat Benign Intracranial Tumors and Trigeminal Neuralgia. Austin J Radiat Oncol & Cancer. 2014, 1(1): 2.

4. Buatti JM, Friedman WA, Bova FJ, Mendenhall WM. Linac radiosurgery for locally recurrent nasopharyngeal carcinoma: rationale and technique. Head Neck. 1995, 17(1): 14-19.

5. Dieterich S, Gibbs IC. The CyberKnife in clinical use: current roles, future expectations. Front of Radiat Ther Oncol. 2011, 43: 181-194.

6. Jeong S, Yoo EJ, Kim JY, Han CW, Kim KJ et al. Re-irradiation of unresectable recurrent head and neck cancer: using Helical Tomotherapy as image-guided intensity-modulated radiotherapy. Radiat Oncol J. 2013, 31(4): 206-215.

7. Stuschke M, Kaiser A, Abu-Jawad J, Pottgen C, Levegrun S et al. Re-irradiation of recurrent head and neck carcinomas: comparison of robust intensity modulated proton therapy treatment plans with helical tomotherapy. Radiat Oncol (London, England). 2013, 8: 93.

8. Lin YW, Lin KH, Ho HW, Lin HM, Lin LC et al. Treatment plan comparison between stereotactic body radiation therapy techniques for prostate cancer: Non-isocentricCyberKnife versus isocentric. Rapid Arc Phy Med. 2014, 30(6): 654-661.

9. Friedland JL, Freeman DE, Masterson-McGary ME, Spellberg DM. Stereotactic body radiotherapy: an emerging treatment approach for localized prostate cancer. Technology in Cancer Research & Treatment. 2009, 8(5): 387-392.

10. Thariat J, Marcy PY, Lacout A, Ramus L, Girinsky T et al. Radiotherapy and radiology: joint efforts for modern radiation planning and practice. DiagnInterv Imaging. 2012, 93(5): 342-350.

11. Stoker SD, van Diessen JN, de Boer JP, Karakullukcu B, Leemans CR et al. Current treatment options for local residual nasopharyngeal carcinoma. Curr Treat Options Oncol. 2013, 14(4): 475-491.

12. Suarez C, Rodrigo JP, Rinaldo A, Langendijk JA, Shaha AR et al. Current treatment options for recurrent nasopharyngeal cancer. Eur Arch Otorhinolaryngol. 2010, 267(12): 1811–1824.

13. Tharavichtikul E, Meungwong P, Chitapanarux T, Chakrabandhu S, Klunklin P et al. The association of rectal equivalent dose in 2 Gy fractions (EQD2) to late rectal toxicity in locally advanced cervical cancer patients who were evaluated by rectosigmoidoscopy in Faculty of Medicine, Chiang Mai University. Radiat Oncol J. 2014, 32(2): 57-62.

14. Niyazi M, Flieger M, Ganswindt U, Combs SE, Belka C. Validation of the prognostic Heidelberg re-irradiation score in an independent mono-institutional patient cohort. Radiat Oncol. 2014, 9(1): 128.

15.Mantel F, Flentje M, Guckenberger M. Stereotactic body radiation therapy in the re-irradiation situation--a review. Radiat Oncol. 2013, 8: 7.

16.Benedict SH, Yenice KM, Followill D, Galvin JM, Hinson W et al. Stereotactic body radiation therapy: the report of AAPM Task Group 101. Med Phys. 2010, 37(8): 4078-4101.

17. Marks LB, Yorke ED, Jackson A, Ten Haken RK, Constine LS et al. Use of normal tissue complication probability models in the clinic. Int J Radiat Oncol Biol Phys. 2010, 76(3 Suppl): S10-S9.

18. Abusaris H, Storchi PR, Brandwijk RP, Nuyttens JJ. Second re-irradiation: efficacy, dose and toxicity in patients who received three courses of radiotherapy with overlapping fields. Radiother Oncol. 2011, 99(2): 235-239.

19. Karam I, Nichol A, Woods R, Tyldesley S. Population-based outcomes after whole brain radiotherapy and re-irradiation in patients with metastatic breast cancer in the trastuzumab era. Radiat Oncol. 2011, 6: 181.

20. Wowra B, Zausinger S, Drexler C, Kufeld M, Muacevic A et al. CyberKnife radiosurgery for malignant spinal tumors: characterization of well-suited patients. Spine (Phila Pa 1976). 2008, 33(26): 2929-2934.