Evaluation of Dose Variation in Head & Neck Patients During their Course of Treatment

Vandana Puri R.T., (R)(M)(T), Pasquale Montanaro M.S., (DABR)

Texas Oncology, Presbyterian Cancer Center Dallas

THE UNIVERSITY OF TEXAS MD Anderson Cancer Center

ABSTRACT

The purpose of this research is to assess the dose variations in head and neck patients during their treatment due to anatomical changes, differences in setup during the course of treatment and/or tumor changes. To evaluate the variation in dose, metrics for the planned target volume (PTV), parotids and the spinal cord were recorded for the original plan on the planning CT and the original plan on Cone Beam CTs taken throughout the course of treatment. Adaptive planning is becoming a popular choice for clinicians to take into account with the aid of the onboard cone beam CT ***(CBCT)***. In this research, weekly CBCT images (5,10,15,20 and 25th fractions) were registered with the planned CT in the Pinnacle planning treatment system. The original plan information was copied to the registered image, calculated homogeneously, and contours were adjusted near the skin and at the edges of the treatment field for comparison purposes. Evaluations on two head and neck patients were measured with two different planning techniques, one with 7 equally spaced IMRT fields and the other with 3 partial VMAT arcs. Upon review, there was variability in dose for head and neck patients over the course of their treatment for both the tumor volumes and critical organs at risk. In one patient, D90 ranged from 5500 to 5922 cGy, cord doses ranged from 44286 cGy to 4399 cGy and mean left parotid dose ranged from 947 cGy to 1437 cGy when being normalized to 33 fractions. Treatment variability is due to changes in anatomy, the ability to set the patient up consistently and possibly differences in planning techniques. Variability was greater with 3 partial arc VMAT plan when comparing it to the IMRT plan.

CONTACT

Vandana Puri
Texas Oncology – Dallas
vpuri@mdanderson.org
MEDDOS–D-19-00075

INTRODUCTION

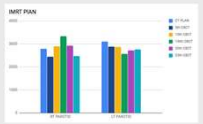
The purpose of this research is to evaluate the variations in dose distributions in head and neck patients over the course of their treatment due to anatomical and/or tumor changes. The strategy is to review the planning target volume (PTV) coverage, measure the mean dose to the parotids, and evaluate the spinal cord – a sensitive structure in high dose regions. Head and Neck patients are treated with Intensity Modulated Radiation Treatment (IMRT) plans that significantly assist physicians in sparing organs at risk (OARs) while the tumor is irradiated to the full extent. Along with IMRT, daily imaging has advanced from 2D imaging to 3D imaging on the treatment table. A highly valuable 3D medical imaging technique is Cone Beam Computed Tomography (CBCT). CBCT benefits the patient and radiation oncology personnel by discovering setup uncertainties and ensuring the correct treatment. Ongoing advancements in therapy and imaging will help to reduce margins and escalate dose to the tumor.

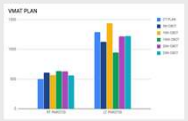
METHODS AND MATERIALS

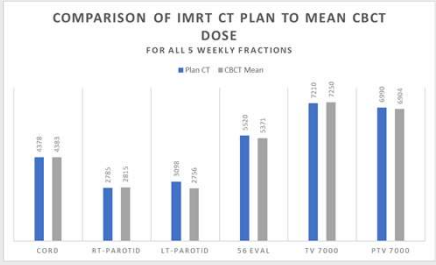
In this research, data was received from 2 head and neck patient plans to evaluate dosimetric variations with definitive radiotherapy using IMRT and VMAT planning technique. The IMRT plan was prescribed to 70 Gy, 200 cGy per fraction and the partial VMAT plan was prescribed to 59.4 Gy, 180 per fraction. Head and neck patients were simulated as per protocol, supine with an immobilization mask and shoulder pull handles on a helical CT. Each planned CT was fused with a positron emission tomography (PET) CT scan. Weekly CBCT images (5 sets) for each patient were sent over to the pinnacle planning system (V9.10) for image registration with respect to the planned CT to evaluate the maximum dose to the cord, mean dose to the right/left parotids, and tumor coverage volume. Planned CT and CBCT images were matched to the spinal cord. Exact monitor units of the planned CT were inserted for each fraction to allow for comparable results under homogenous conditions. Contours were evaluated and adjusted for comparison purposes. Slices with the greatest uncertainty due to CBCT quality were removed from both planning and treatment images. The tumor coverage volume and doses from the planned CT were recorded to help analyze the dosimetric impact from the dose volume histogram on the weekly CBCT delivered plans.

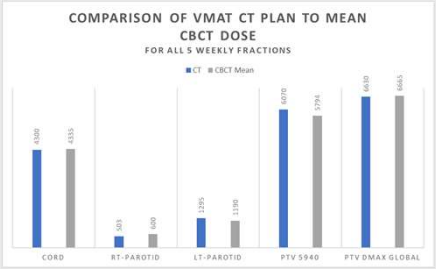
RESULTS

Dosimetric changes were seen upon evaluation of the cord, parotid glands, and tumor volume coverage amongst the two head and neck plans. In the IMRT plan, the mean dose to the right parotid ranged from 2449 cGy to 2925 cGy as compared to with the planned CT with a mean dose of 2785 cGy. Similarly, the mean dose to the left parotid in the CBCT IMRT plans ranged from 2569 cGy to 2879 cGy against the planned CT mean dose of 3098 cGy. The max cord dose varied from 4246 cGy to 4694 cGy while the planned CT max dose measured 4378 cGy. Tumor volumes of TV70 Gy D90 ranged 6697 cGy to 7055 cGy as compared to 6990 cGy in the planned CT. Tumor volumes of 56 Gy (boost) D90 ranged 5144 cGy to 5550 cGy in comparison to 5520 cGy in the planned CT. These numbers reflect a definite change due to anatomical and setup variations. In the VMAT planning, the mean dose to the right parotid ranged from 561 cGy to 633 cGy as compared to with the planned CT with a mean dose of 503 cGy. Similarly, the mean dose to the left parotid ranged from 947 cGy to 1437 cGy against the planned CT mean dose of 1295 cGy. The max cord dose varied from 4286 cGy to 4399 cGy while the planned CT max dose measured 4300 cGy. Tumor volumes D90 ranged from 5500 cGy to 5922 cGy as compared to the planned CT of 6070 cGy.









DISCUSSION

In this study, results showed dosimetric variability throughout the course of treatment for head and neck radiotherapy delivered by IMRT or VMAT. Variation was larger for certain anatomical structures than others, however, over the course of treatment, the largest deviation from the IMRT plan was the left parotid value by 242 cGy and the smallest deviation was the max dose cord value by 5 cGy. The largest deviation from the VMAT plan was the PTV 5940 by 276 cGy and the smallest deviation was the max dose cord and dmax global value by 35 cGy when each fraction was summed and averaged simulating the entire treatment. Because our research showed little less than clinically significant variation in dose to critical structures and tumor volumes, additional studies should be performed to help indicate when re-planning should occur. Certain measures such as skin separation and tumor shrinkage could be measured and evaluated with respect to dose variation.

CONCLUSIONS

It is imperative to image these patients on a daily basis to adapt to the intended plan as tighter tumor volumes show a greater difference on a weekly basis. Research correlating the dose actually received by organs with clinical results such as xerostomia, dysphagia and tumor control is justified. The variation in dose deposition between the two different planning techniques along with tumor location is also noticed. The tumor location for the IMRT plan is centralized whereas the tumor location for the partial VMAT is on the left side. In the IMRT CBCT plans, both parotids are under dosed whereas in the VMAT CBCT plans due to tumor being on the left side, the right parotid received over the planned dose and the left parotid received less at a given point portraying a possible effect of partial arcs.

REFERENCES

1. Ahn, P.H., Chen, C., Ahn, A., Eng, M., Hong, L., Scripes, P.G., Shen, J., Lee, C., Miller, E., Kalnicki, S., & Garg, M., (2011). Adaptive planning in intensity-modulated Radiation Therapy for Head and Neck cancers: Single-Institution experience and clinical implications. International Journal Radiation Oncology. 80:3, 677-685. doi: 10.1016/j.ijrobp.2010.03.014
2. Brouwer, C.L., Steenbakker, R.J.H.M., Schaaf, A., Sopacua, C.T.C., Dijk, L.V., Kierkels, R.G.J., Bijl, H.P., Burgerhof, J.A., Langendijk, J.A., & Sijtsema, N.M., (2016). Selection of head and neck cancer patients for adaptive radiotherapy to decrease xerostomia. Radiotherapy and Oncology. 120, 36-40.
3. Brown E. Owen, R., Harden, F., Mengersen, K., Oestreich, K., Houghton, W., Poulsen, M., Harris, S., Lin, C., & Porceddu, S., (2015). Predicting the need for adaptive radiotherapy in head and neck cancer. Radiotherapy and Oncology. 116, 57-63.
4. Ho, K.F., Marchant, T., Moore, C., Webster, G., Rowbottom, C., Penington, H., Sc, B., Lee, L., Yap, B., Skyes, A., & Slevin, N., (2012). Monitoring Dosimetric Impact of Weight Loss With Kilovoltage (KV) Cone Beam CT (CBCT) During Parotid-Sparing IMRT and Concurrent Chemotherapy. International Journal Radiation Oncology Biology Physics.82:3, 375-382.
5. Hvid, C.A., Elstrom, U.V., Jensen, K. & Grau, C., (2018). Cone-beam computed tomography (CBCT) for adaptive image guided head and neck radiation therapy. Acta Oncologica. 57:4, 552-556. doi:10.1080/0284186X.2017.1398414
6. Kranen, S.V., Mencarelli, A., Beek, S.V., Rasch, C., Herk, M.V., & Sonke, J.J., (2013). Adaptive radiotherapy with an average anatomy model: Evaluation and quantification of residual deformations in head and neck cancer patients. Radiotherapy and Oncology. 109, 463- 468.
7. Sherpe, M.B., Brock, K.K., Rehbinder, H., Forsgren, C., Dawson, L.A., Studer, G., O'Sullivan, B., McNutt, T.R., Kaus, M.R., Lof, J., & Jaffray, D.A., (2005). Adaptive Planning and Delivery to Account for Anatomical Changes Induced by Radiation Therapy of Head and Neck Cancer. International Journal of Radiation Oncology. 63, S3.