Journal of Radiation Research and Applied Sciences 8 (2015) 55–60

HOSTED BY

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Journal of Radiation Research and Applied Sciences

journal homepage: http://www.elsevier.com/locate/jrras

Assessment of brain dose distribution for ARC and conformal radiation therapy (CRT): A comparison study

Tamer Dawod [1], *Rehab Omar* [*]

Clinical Oncology and Nuclear Medicine Department, Faculty of Medicine, Mansoura University, Egypt

ARTICLE INFO

Article history:
Received 13 September 2014
Accepted 25 October 2014
Available online 11 November 2014

Keywords:
Brain tumor
Arc therapy
Conformal therapy

ABSTRACT

Objective: This study evaluates the dose distribution of the three-dimensionally planned conformal radiation therapy (CRT) compared to the previously used (5 years ago) arc radiotherapy (ARCRT) of the brain cancer patients in Clinical Oncology and Nuclear Medicine Department – Mansoura University.

Patients and methods: Thirty-three unselected brain cancer patients were planned by both the standard CRT and ARCRT techniques for radiotherapy of the brain. Dose–volume histograms were carried out by the 3D treatment planning system. They were assessed for the GTV, CTV, PTV and organs at risk. The prescribed total dose was 60 Gy in 30 fractions.

Results: Comparing different DVHs, it was found that, the GTV, CTV and PTV were adequately covered in both (CRT & ARCRT) plans while it was demonstrated that ARCRT produced superior distribution compared to CRT technique, with considerable sparing of organ at risk.

Conclusion: The tangential beam ARCRT planning demonstrated a significantly better homogeneity index for the GTV, CTV, and PTV of the brain cancer patients with a significant reduction in the mean doses of the both eyes, optic nerves, optic chiasm and brain stem.

1. Introduction

Approximately 50% of patients diagnosed for cancer receive radiotherapy as a part of their oncologic management. So, balancing the potential for early and late toxicity against tumor control is particularly important (Syam Kumar, Holla, Sukumar, Padmanaban, & Vivekanandan, 2013).

Radiation therapy is a mainstay of the management of most malignant and a significant number of benign primary CNS tumors. Radiotherapy may be the main treatment if the brain tumor can't be removed with surgery. It's also often used after surgery to treat any cancer cells that may have been left behind, and can sometimes be used if the tumor has come back after surgery. Radiotherapy may sometimes be given along with chemotherapy tablets to some people with high-

* *Corresponding author*. Clinical Oncology and Nuclear Medicine Department, Mansoura University Hospitals, Egypt. Tel.: +20 1142205525.

E-mail addresses: tamerdawod@gmail.com (T. Dawod), ro_elsayed@yahoo.com (R. Omar).

Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications.

[1] Tel.: +20 1006733357.

http://dx.doi.org/10.1016/j.jrras.2014.10.008

grade gliomas. The length of treatment will depend on the type and size of brain tumor, but it is usually 2–6 weeks. Some people will have different treatment plans and may have treatment on only three days a week (Khan, 2007; Levitt, Purdy, Perez, & Vijayakumar, 2006). There has been a general change in treatment planning from 2D using a simulator to 3D based on a CT scan and it has been shown that virtual simulation of cancer patients may be more time effective (Buchali et al., 2001). The technological development of accelerators with multi-leaf collimators has also offered some new possibilities for more time saving treatment techniques compared to techniques with field matching between photon and electron fields (Sonnik et al., 2007).

Rotation therapy is a special case of the isocentric technique in which the beam moves continuously about the patient, or the patient is rotated while the beam is held fixed. Although this technique has been used for treating tumors of the esophagus, bladder, prostate gland, cervix, and brain, the technique offers little advantage over the isocentric technique using multiple stationary beams. Rotation therapy is best suited for small, deep-seated tumors. If the tumor is confined within a region extending not more than halfway from the center of the contour cross-section, rotation therapy may be a proper choice. However, rotation therapy is not indicated if (a) volume to be irradiated is too large, (b) the external surface differs markedly from a cylinder, and (c) the tumor is too far off center (Khan, 1994).

The goal of three-dimensional conformal radiation therapy (3D-CRT) is to increase the likelihood of tumor control while minimizing irradiation of normal surrounding tissues by precise conforming the dose distribution to the target volume shape (Marks et al., 2000; Mileusnić, 2005).

Dose–volume histograms (DVHs) are commonly used to compare radiation treatment beams designed using traditional techniques with those planned using 3D tools. The structures chosen for the DVHs comparison are typically those that are incidentally irradiated using traditional methods (Awad, Zayed, Abotouk, & Dawood, 2012; Donovan et al., 2007).

This study evaluates the dose distribution of planned conformal radiation therapy (CRT) compared to arc radiotherapy (ARCRT) of the brain and through its effect on target coverage and normal tissue sparing for cancer patients.

2. Patients and method

CT datasets of 33 patients with brain cancer who received radical radiotherapy treatment in our department were randomly selected for this comparative planning study. All patients underwent CT simulation; 3 mm slice thickness in the supine position on the brain board. The instructions for the PTV delineation were strictly followed in accordance with the ICRU-62 guidelines. Gross tumor volume (GTV)-to clinical target volume (CTV) margins of 10 mm were applied. Margins of 5 mm were added to generate the planning target volume (PTV) primarily in order to account for target motion (Cacicedo et al., 2014; ICRU, 1999; Lee et al., 2007; Soyfer et al., 2012).

Organs at risk (OAR); right eye, left eye, right optic nerve, left optic nerve, optic chiasm and brain stem were delineated. 3D conformal plans and conventional ARC plans were calculated with the integrated full area based commercial planning system precise plan developed by ELEKTA. Conventional arc modulation is optimized with variation of gantry position with conventional jaw-positions and collimator angle. Two plans were subsequently generated using consistent planning parameters such as field arrangements, optimization parameters and beam weights. First, a 3D plan using 2–3 conformal beams (ELEKTA). Second, a conventional arc therapy using 1–3 beams. The dose calculations were performed using homogeneity corrections and full integrated area algorithm. Physicians selected the preferred plan after comparing dose distributions by carefully assessing the best DVHs with attention to V_5, V_{10}, V_{20}, and V_{50} to OAR and Mean dose, for target volumes the comparison made between maximum dose, minimum dose, mean dose, conformity index, homogeneity index, and uniformity index. The parameters used for target volumes were V_{95}, $D_{2\%}$, $D_{5\%}$, $D_{50\%}$, $D_{95\%}$, and $D_{98\%}$. The most frequently selected energy of photons was 6 MV. The number of the fields per planning was 2–3 for the conformal 3D, 1–3 for conventional ARC therapy.

Conformity index (CI), represents an attempt to measure objectively how well the distribution of radiation follows the shape of target, which is a ratio of the volume of tissue receiving at least 95% of the prescribed dose divided by the volume of the PTV (Equation (1)). A CI value closer to 1 is more conformal (Foroudi et al., 2012).

$$\mathrm{CI} = \frac{V_{95\%}}{V_{\mathrm{PTV}}} \tag{1}$$

The homogeneity index (HI) was also calculated and is the difference between the near-maximum and near-minimum dose normalized to the median dose (Equation (2)) and measures the dose homogeneity across the PTV. An HI value approaching zero indicates a more homogenous dose distribution within the PTV (Foroudi et al., 2012; Wu, Mohan, Morris, Lauve, & Schmidt Ullrich, 2003).

$$\mathrm{HI} = \frac{D_{2\%} - D_{98\%}}{D_{50\%}} \tag{2}$$

where $D_{2\%}$ and $D_{98\%}$ represent the doses to 2% and 98% of the PTV, respectively. For example, D_{98} indicates that at least 98% of the target volume receives this dose, and hence $D_{2\%}$ and $D_{98\%}$ are considered to be the maximum and minimum doses, respectively. Equation (2) shows that lower HI values indicate a more homogenous target dose (Yoon et al., 2007).

$$\mathrm{UI} = \frac{D_5}{D_{95}} \tag{3}$$

where D_5 and D_{95} are the minimum doses delivered to 5% and 95%, respectively of the PTV as previously described by Sheng et al. (2007) and Wang, Zhang, and Dong (2005). The values of the above parameters of 33 patients planned by ARC therapy with CRT technique were compared with the help of their dose volume histograms. The statistical approach was to extract the two-tailed p-value via independent T testing, using two-sample distributions assuming unequal variances, A p-value of $p < 0.05$ was considered statistically significant.