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Original research article

Superior sulcus non-small cell lung carcinoma: A comparison of IMRT and 3D-RT dosimetry

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ABSTRACT

Aim: A dosimetric study comparing intensity modulated radiotherapy (IMRT) by TomoTherapy to conformational 3D radiotherapy (3D-RT) in patients with superior sulcus non-small cell lung cancer (NSCLC).

Background: IMRT became the main technique in modern radiotherapy. However it was not currently used for lung cancers. Because of the need to increase the dose to control lung cancers but because of the critical organs surrounding the tumors, the gains obtainable with IMRT is not still demonstrated.

Material and methods: A dosimetric comparison of the planned target and organs at risk parameters between IMRT and 3D-RT in eight patients who received preoperative or curative intent irradiation.

Results: In the patients who received at least 66 Gy, the mean V95% was significantly better with IMRT than 3D-RT ($p = 0.043$). IMRT delivered a lower D2% compared to 3D-RT ($p = 0.043$). The IH was significantly better with IMRT ($p = 0.043$). The lung $V_{5\,Gy}$ and $V_{13\,Gy}$ were significantly higher in IMRT than 3D-RT ($p = 0.043$), while the maximal dose (D_{max}) to the spinal cord was significantly lower in IMRT ($p = 0.043$). The brachial plexus D_{max} was significantly lower in IMRT than 3D-RT ($p = 0.048$). For patients treated with 46 Gy, no significant differences were found.

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Conclusion: Our study showed that IMRT is relevant for SS-NSCLC. In patients treated with a curative dose, it led to a reduction of the exposure of critical organs, allowing a better dose distribution in the tumor. For the patients treated with a preoperative schedule, our results provide a basis for future controlled trials to improve the histological complete response by increasing the radiation dose.

1. Background

Superior sulcus non-small cell lung cancer (SS-NSCLC) is a rare tumor, representing less than 5% of all NSCLC. By definition, these tumors invade the thoracic wall and are close to, abut or infiltrate the spinal cord, the brachial plexus and/or the esophagus. The tumor size, the respiratory motion in the irradiation fraction and the dose-constraints to reach a curative tumor dose are all limiting factors that prevent the delivery of safe and optimal irradiation with a radiation therapy conformal 3D (3D-RT) technique. Intensity modulated radiation therapy (IMRT) allows a homogeneous, high dose gradient to be delivered for cases of advanced NSCLC, leading to a better target volume coverage and a higher shielding of the surrounding critical organs.[1–5]

To improve the local and regional control rates, many centers have initiated dose escalation trials in stage III NSCLC patients to observe the feasibility and safety constraints of concurrent chemoradiotherapy at higher doses. Most concluded that 74 Gy was a tolerable dose in well-controlled setups of 3D-RT.[6–9] From a study including 106 NSCLC patients at the University of Michigan, Kong et al. reasoned that each 1 Gy increase in the dose administered improved the five-year local control rate by 1.25% and decreased the death risk by 3%.[7] This suggested that higher radiation doses were associated with better outcomes. However, in the RTOG 0617 trial, 74 Gy given in 2 Gy fractions with concurrent chemotherapy was not better than 60 Gy plus concurrent chemotherapy for patients with stage III non-small-cell lung cancer, and was considered to be potentially harmful.[10] The use of 3D-RT could be one of the reasons for the failure of this increased dose. In the case of SS-NSCLC, an increased dose could be relevant if it leads to increase the operability for otherwise inoperable patients or for those with pT0 tumors which should improve the patients outcomes.[11]

Because of the conformality, of its dramatic dose-gradient, IMRT requires a very precise set-up of the patient and strict control of the treated targets. Image-guided radiotherapy (IGRT) is the most secure system available that meets all of the required security controls. Tomotherapy combines IMRT and IGRT.[12]

2. Aim

IMRT is still not considered a reference treatment for SS-NSCLC. In the current study, we analyzed the dosimetric parameters by comparing Tomotherapy and 3D-RT in SS-NSCLC treated preoperatively or with curative intent.

3. Material and methods

Between January 2007 and January 2010, eight patients with a median age of 54.3 years (43–75) were treated with IMRT with TomoTherapy HiArt® device (Accuray Incorporated, Sunnyvale, CA). There were seven adenocarcinomas and one squamous cell carcinoma. The tumors were classified as IIB, IIIA, IIIB and IV stages in one, two, one and four patients, respectively. Six patients received chemoradiation alone, one received radiation alone and the last one received preoperative chemoradiation. The chemotherapy comprised a combination of cisplatin and vinorelbine.

3.1. Simulation

All patients underwent CT simulation using a General Electric (GE) light-speed scanner (General Electric, Milwaukee, WI) in the supine position. Injected and non-injected CT scans were both obtained. All but two patients underwent free-breath CT scans and the other two underwent a three-sequences CT scan (deep inspiration/expiration and free breath-hold). The slices depths were 2.5–3.75 mm.[13] ^{18}Fluoro Desoxy-Glucose PET-CT for delineation was performed in seven patients.

3.2. Target-volumes definition

The delineation of the target volumes was performed using the Focal software program (Elekta AB, Stockholm, Sweden). The gross tumor volume (GTV_{tumor}) was the tumor volume in the free-breath simulation CT scan or the combination of the three volumes in the three sequences simulation CT-scan (equivalent to an internal target volume). PET-CT images were matched with the simulation CT scan. The biological tumor volume represented 40% of the maximal standard unit value (SUV_{max}). All nodes $\leq$10 mm or $\geq$20 mm and ^{18}Fluoro Desoxy-Glucose avid, and all 10–19 mm nodes (avid or not) were considered to be metastatic and were included in a GTV_{node}.[14]

The clinical target volume for the tumor (CTV_{tumor}) was the GTV_{tumor} plus a margin of 6 or 8 mm according to Giraud et al.[15] and was corrected to the relevant anatomical border. The CTV for adenopathies ($CTV_{adenopathies}$) was the area where adenopathies developed and were delineated according to the report by Chapet et al.[16] No prophylactic node volume was defined.[17] The planning target volume for the tumor and nodes ($PTV_{tumor+adenopathies}$) was obtained by adding an isotropic 2 mm margin to the $CTV_{(tumor+node)}$ equal to ($CTV_{tumor} + CTV_{adenopathies}$) when a three-sequences CT-scan was used, and 10 mm cranio-caudal and 5 mm axial