2066 POSTER

Lung Stereotactic Body Radiation Therapy − Ensuring Accurate Target Volume Delineation

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Background: Four-dimensional computed tomography (4DCT) is increasingly used to account for intrafractional tumour mobility from respiratory motion in lung stereotactic body radiation therapy. For rapid generation of an internal tumour volume (ITV), some institutions frequently use a maximum intensity projection (MIP) image set created from the 4DCT. The purpose of this study is to compare the ITV generated using the MIP to an ITV generated from contouring the gross tumour volume in each of the 10 phases of the 4DCT acquisition.
Materials and Methods: 4DCT image data sets of 16 lesions in 9 patients with primary or metastatic lung tumours amenable to high-dose image-guided hypofractionated radiotherapy treatment were analyzed. For each lesion, an ITV was generated using the single MIP image (ITV-MIP) and a composite ITV was formed from delineating the gross tumour volume on each of the 10 phases of the 4DCT (ITV-10phase). Analysis of target volumes was performed by comparing the volumes of the two ITVs created for each lesion. Algebraic operators on the Varian Eclipse system were also used to examine the volume encompassed by ITV-10phase but not by ITV-MIP and, similarly, the volume encompassed by ITV-MIP but not ITV-10phase. The data was also analyzed by tumour location characteristics.
Results: Overall, the delineated ITV-10phase volume was equal or greater than the ITV-MIP volume for each case. The mean ratio of the volume of ITV-10phase to ITV-MIP was 1.21 with a standard deviation of $\pm$0.22 (ideal ratio = 1.00 when ITV-10phase is identical to ITV-MIP). For the subgroup of well-defined peripheral lesions (n = 7), further algebraic analyses revealed that the median percentage of potential gross tumour not covered by the MIP was 3.3% (range 1.0–10.9%). For the subgroup of tumours near the diaphragm or mediastinum (n = 5), the median percentage of potential gross tumour not covered by the MIP was 18.8% (range 10.7–39.6%). However, only 1.5% (range 0.7−3.8%) and 0.7% (range 0.3−2.6%) of the ITV-MIP was not covered by the ITV-10phase for the above subgroups, respectively.
Conclusions: Caution must be exercised when using MIP to delineate ITV to avoid under treatment of gross disease. For well-defined peripheral lesions entirely surrounded by low density lung parenchyma, an ITV generated from the MIP represented a relatively accurate estimate of the composite ITV created from each of the 10 phases of a 4DCT. However, significant differences in delineation occurred in cases where the lesion adjoined normal tissue structures with a similar density to tumour. In such cases, the MIP cannot be reliably used to delineate ITV.

2067 POSTER

Predictors of Peritumoral Edema After Stereotactic Radiosurgery for Benign Brain Tumours

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Background: Peritumoral edema (PTE) is a well known adverse effect of stereotactic radiosurgery (SRS) for benign brain tumours. The aim of this study was to evaluate the potential risk factors of PTE after SRS for benign brain tumours.
Materials and Methods: The records of 45 patients with 48 benign brain tumours managed with linear accelerator-based SRS were retrospectively reviewed. Meningioma, cavernous hemangioma, arteriovenous malformation and schwannoma were included. A median marginal prescribed dose, 16.2 Gy (12.6–21.6 Gy), was delivered in 1 fraction. Median follow up period was 23.6 month (9.3–37.8 month). The incidence of overall PTE, symptomatic PTE and potential risk factors for PTE were analyzed using simple and multiple logistic regression analysis.
Results: Of the 48 cases, 13 (27%) developed overall PTE and 8 (16.7%) developed symptomatic PTE. Tumour volume (p = 0.033, odds ratio(OR)=1.216), parasagittal location of tumour (p = 0.003, OR=21.7), V18 (normal brain tissue volume receiving more than 18 Gy (p = 0.004, OR=1.672)), V15 (p = 0.006, OR=1.362), V10 (p = 0.012, OR= 1.184), D10cc (minimum dose in the most irradiated 10 cc volume of normal brain tissue (p = 0.003, OR=1.798)), D20cc (p = 0.002, OR=1.782), D30cc (p = 0.004, OR=1.694) were related to occurrence of symptomatic PTE in simple logistic regression analysis. Maximum normal tissue dose was not related with symptomatic PTE (p = 0.094). Only D20cc (p = 0.016, OR=7.362) was associated with occurrence of symptomatic PTE in multiple analysis. For overall PTE, V18 (p = 0.02, OR=1.392), V15 (p = 0.026, OR=1.201), V10 (p = 0.016, OR= 1.125), D10cc (p = 0.008, OR=1.320), D20cc (p = 0.007, OR=1.372), D30cc (p = 0.014, OR=1.402) and parasagittal location of tumour (p = 0.012, OR=18.86) were all related to occurrence of overall PTE in simple analysis. In multiple analysis, parasagittal location of tumour (p = 0.012, OR=24.085) affected the occurrence of overall PTE.
Conclusions: D20cc and parasagittal location of tumour were important risk factors for the development of symptomatic PTE and overall PTE after SRS, respectively. To decrease the development of PTE, the effort to decrease the volume of normal brain tissue that received high dose radiation and to reduce dose in adjacent normal brain are needed. And more caution is needed for tumours in the parasagittal location.

2068 POSTER

Dosimetric Features of RapidArc Plan Using Different Internal Target Volume in Radiotherapy of Hepatocellular Carcinoma

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Purpose: To investigate the dosimetric features of RapidArc plans for hepatocellular carcinoma (HCC) radiotherapy using different target volumes which determined by four dimension computed tomography (4D-CT) and 3D-CT.
Methods: 12 patients with HCC were selected to undergo 4D-CT and 3D-CT simulation associated with ABC in end inspiration hold (EIH), end expiration hold (EEH), and free breathing (FB). The GTVs were contoured on 4D-CT and 3D-CT images respectively, and the internal gross target volume (ITV_1, ITV_2) were acquired respectively. The individual margins were obtained from GTV_{FB} to ITV_1 and ITV_2, ITV_3 and ITV_4 were obtained from GTV_{FB} plus the individual margins respectively. PTV_{-1} was acquired from GTV_{FB} using conventional margins; and PTV_{-2} using individual margins and PTV_{-3} was acquired from GTV_{EIH}. For the PTV_{-1} and PTV_{-3}, RapidArc plan with three 135º arcs (ARC_1, ARC_4) were designed; for PTV_{-1} and PTV_{-2} with 360º arc (ARC_2, ARC_3). The volume of GTVs, ITVs, PTVs, the individual margins and the dosimetric features of four RapidArc plans were compared.
Results: The volume differences between ITV_1 and ITV_2, ITV_3 and ITV_4 were not significant ($p > 0.05$). The volume of PTV_{-1} was larger than PTV_{-2}, PTV_{-3} ($p < 0.05$). The three axial margins differences from GTV_{FB} to ITV_1 and ITV_2 were not significant ($p > 0.05$). The differences of dose distribution for target volume in four plans were not significant ($p > 0.05$). The differences of OARs irradiation dose of ARC_1 and ARC_2 were not significant ($p > 0.05$). The dose of normal liver was ARC_1 >ARC_3 >ARC_4 ($p < 0.05$).
Conclusions: 3D-CT associated with ABC could achieve the determination of individual internal target volume and individual margins for HCC comparing with 4D-CT. Associated with ABC or using individual target volume determined by 3D-CT associated with ABC or 4D-CT in RapidArc plan for HCC radiotherapy can achieve perfect target dose coverage and spare more OARs.

2069 POSTER

An Effective Way for Hepatocellular Carcinoma (HCC) Radiotherapy: RapidArc Combined With Active Breathing Coordinator

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Background and Purpose: To investigate the feasibility of RapidArc (RA) assisted by active breathing control (ABC) for hepatocellular carcinoma (HCC) radiotherapy.
Methods: Twelve patients with HCC after TACE underwent 3D-CT scanning assisted by ABC at end inspiration hold (EIH), end expiration hold (EEH), and free breathing (FB). Three treatment plans were designed as 3D-CRT, IMRT, and RA. The volumes of liver, normal liver (the liver volume minus the PTV), GTV, PTV in three breathing status were compared. The conformity index (CI), the dose homogeneity index (HI) of target volume, and the maximum dose, minimum dose, the monitor unit, treatment time, the dose-volume parameters of normal liver, stomach, duodenum were compared.
Results: There was no significant difference in the volumes of liver, normal liver, and GTV at three breathing status ($p > 0.05$); but the PTV at FB was larger than that at EEH and EIH ($p < 0.05$), The overall CI and HI for RA was better than IMRT and 3D-CRT at three breathing status ($p < 0.05$). The mean dose, V_{20}, V_{30}, V_{40} of normal liver were 3D-CRT > RA > IMRT ($p < 0.05$). For the mean normal liver dose, the V_{10} was FB > EEH > EIH. For the V_{20}, V_{30} and V_{40} of normal liver at FB was greater than that of EEH and EIH. The $D_{5\,cm^3}$ of duodenum was EIH > FB > EEH ($p < 0.05$). The monitor unit for IMRT, RA and 3D-CRT