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Current Journals: Tables of Contents

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Stereotactic body radiation therapy for lung tumors

Authors: Josh H Heinzerling, MD; Robert D Timmerman, MD

All topics are updated as new evidence becomes available and our peer review process is complete.

Literature review current through: Jan 2018. | This topic last updated: Jan 26, 2018.

Summary

Seeking patient consent prior to undertaking an examination or treatment procedure is not only a fundamental, ethical and legal requirement of all healthcare practitioners, it is also a common courtesy as part of the process of creating a relationship of trust between healthcare practitioners and the patient or service user. When carrying out any procedure, the healthcare practitioner is ultimately responsible for ensuring that the patient or service user is genuinely consenting to the procedure being undertaken; it is they who will be held responsible in law if this is later challenged.
Recent Database Articles

Below is a selection of articles recently added to the healthcare databases, relating to:

**Intra-fractional imaging (cone beam CT) in radiotherapy for SABR patients/ lung patients**

If you would like any of the articles in full text, or if you would like a more focused search on your own topic, please contact us: library@bristol.nhs.uk

1. **Accuracy of radiotherapy dose calculations based on cone-beam CT: comparison of deformable registration and image correction based methods.**
   - **Author(s):** Marchant, Tom Edward; Joshi, Kiran Daniel; Moore, Christopher J
   - **Source:** Physics in medicine and biology; Feb 2018
   - **Publication Date:** Feb 2018
   - **Publication Type(s):** Journal Article
   - **PubMedID:** 29461255
   - **Abstract:** Radiotherapy dose calculations based on cone-beam CT (CBCT) images can be inaccurate due to unreliable Hounsfield units (HU) in the CBCT. Deformable image registration of planning CT images to CBCT, and direct correction of CBCT image values are two methods proposed to allow heterogeneity corrected dose calculations based on CBCT. In this paper we compare the accuracy and robustness of these two approaches. CBCT images for 44 patients were used including pelvis, lung and head & neck sites. CBCT HU were corrected using a "shading correction" algorithm and via deformable registration of planning CT to CBCT using either Elastix or Niftyreg. Radiotherapy dose distributions were recalculated with heterogeneity correction based on the corrected CBCT and several relevant dose metrics for target and OAR volumes were calculated. Accuracy of CBCT based dose metrics was determined using an "override ratio" method where the ratio of the dose metric to that calculated on a bulk-density assigned version of the same image is assumed to be constant for each patient, allowing comparison to the patient's planning CT as a gold standard. Similar performance is achieved by shading corrected CBCT and both deformable registration algorithms, with mean and standard deviation of dose metric error less than 1 % for all sites studied. For lung images, use of deformed CT leads to slightly larger standard deviation of dose metric error than shading corrected CBCT with more dose metric errors greater than 2 % observed (7 % vs 1 %).
   - **Database:** Medline

2. **Automated ultrafast kilovoltage-megavoltage cone-beam CT for image guided radiotherapy of lung cancer: System description and real-time results.**
   - **Author(s):** Blessing, Manuel; Arns, Anna; Wertz, Hansjoerg; Stsepankou, Dzmitry; Boda-Heggemann, Judit; Hesser, Juergen; Wenz, Frederik; Lohr, Frank
   - **Source:** Zeitschrift fur medizinische Physik; Feb 2018
   - **Publication Date:** Feb 2018
Publication Type(s): Journal Article
PubMedID: 29429610

Abstract: PURPOSE To establish a fully automated kV-MV CBCT imaging method on a clinical linear accelerator that allows image acquisition of thoracic targets for patient positioning within one breath-hold (~15s) under realistic clinical conditions. METHODS AND MATERIALS Our previously developed FPGA-based hardware unit which allows synchronized kV-MV CBCT projection acquisition is connected to a clinical linear accelerator system via a multi-pin switch; i.e. either kV-MV imaging or conventional clinical mode can be selected. An application program was developed to control the relevant linac parameters automatically and to manage the MV detector readout as well as the gantry angle capture for each MV projection. The kV projections are acquired with the conventional CBCT system. GPU-accelerated filtered backprojection is performed separately for both data sets. After appropriate grayscale normalization both modalities are combined and the final kV-MV volume is re-imported in the CBCT system to enable image matching. To demonstrate adequate geometrical accuracy of the novel imaging system the Penta-Guide phantom QA procedure is performed. Furthermore, a human plastinate and different tumor shapes in a thorax phantom are scanned. Diameters of the known tumor shapes are measured in the kV-MV reconstruction. RESULTS An automated kV-MV CBCT workflow was successfully established in a clinical environment. The overall procedure, from starting the data acquisition until the reconstructed volume is available for registration, requires ~90s including 17s acquisition time for 100° rotation. It is very simple and allows target positioning in the same way as for conventional CBCT. Registration accuracy of the QA phantom is within ±1mm. The average deviation from the known tumor dimensions measured in the thorax phantom was 0.7mm which corresponds to an improvement of 36% compared to our previous kV-MV imaging system. CONCLUSIONS Due to automation the kV-MV CBCT workflow is speeded up by a factor of >10 compared to the manual approach. Thus, the system allows a simple, fast and reliable imaging procedure and fulfills all requirements to be successfully introduced into the clinical workflow now, enabling single-breath-hold volume imaging.

Database: Medline

3. Results from a clinical trial evaluating the efficacy of real-time body surface visual feedback in reducing patient motion during lung cancer radiotherapy.

Author(s): Price, Gareth J; Faivre-Finn, Corinne; Stratford, Julia; Chauhan, Sheena; Bewley, Michelle; Clarke, Laura; Johnson, Corinne N; Moore, Christopher J

Source: Acta oncologica (Stockholm, Sweden); Feb 2018; vol. 57 (no. 2); p. 211-218

Publication Date: Feb 2018
Publication Type(s): Journal Article
PubMedID: 28780900

Abstract: INTRODUCTION Optical surface measurement devices are a maturing technology in radiotherapy. The challenge for such devices is to demonstrate how they can improve clinical care. We present results from a phase 1 clinical trial designed to test the hypothesis that if presented with live data from a novel optical measurement device, showing their deviation from an ideal radiotherapy treatment position, patients will be able to better control their motion and increase their geometrical conformance. METHOD AND MATERIALS Fourteen lung cancer patients were enrolled in a prospective clinical study and asked to use a variety of visual feedback schema from a novel in-house developed optical surface measurement device. The magnitude and regularity of their body surface motion using the different schema was compared to that when free-breathing at three time-points throughout their radiotherapy treatment schedule. Additionally, 4D Cone Beam CT data, acquired simultaneously with the optical measurements, was used to test if improvements in
external motion are reflected in changes in internal tumor motion.

RESULTSThe primary endpoint of the trial, device tolerability assessed by the fraction of participants completing all study sessions, was 86%. Secondary endpoints showed that use of the visual feedback device was found to statistically significantly decrease body surface motion magnitude by an average of 17% over the study cohort, although not universally. Similarly body surface motion variability was decreased by 18% on average. Internal tumor motion magnitude was also found to be statistically significantly decreased by an average of 14% when using the feedback device. Reduction in external motion was predictive of reduced internal motion but no evidence of a simple correlation between changes in internal and external motion magnitude was found.

CONCLUSIONSVisual feedback of live motion is well tolerated by lung cancer patients and can reduce both body surface and tumor motion.

Database: Medline

4. Quantification of the kV X-ray imaging dose during real-time tumor tracking and from three- and four-dimensional cone-beam computed tomography in lung cancer patients using a Monte Carlo simulation.

Author(s): Nakamura, Mitsuhiro; Ishihara, Yoshitomo; Matsuo, Yukinori; Iizuka, Yusuke; Ueki, Nami; Irimina, Hiraku; Hirashima, Hideaki; Mizowaki, Takashi

Source: Journal of radiation research; Jan 2018

Publication Date: Jan 2018

Publication Type(s): Journal Article

PubMedID: 29385514

Available at Journal of radiation research - from Oxford Journals - Open Access

Available at Journal of radiation research - from HighWire - Free Full Text

Available at Journal of radiation research - from Europe PubMed Central - Open Access

Abstract: Knowledge of the imaging doses delivered to patients and accurate dosimetry of the radiation to organs from various imaging procedures is becoming increasingly important for clinicians. The purposes of this study were to calculate imaging doses delivered to the organs of lung cancer patients during real-time tumor tracking (RTTT) with three-dimensional (3D), and four-dimensional (4D) cone-beam computed tomography (CBCT), using Monte Carlo techniques to simulate kV X-ray dose distributions delivered using the Vero4DRT. Imaging doses from RTTT, 3D-CBCT and 4D-CBCT were calculated with the planning CT images for nine lung cancer patients who underwent stereotactic body radiotherapy (SBRT) with RTTT. With RTTT, imaging doses from correlation modeling and from monitoring of imaging during beam delivery were calculated. With CBCT, doses from 3D-CBCT and 4D-CBCT were also simulated. The doses covering 2-cc volumes (D2cc) in correlation modeling were up to 9.3 cGy for soft tissues and 48.4 cGy for bone. The values from correlation modeling and monitoring were up to 11.0 cGy for soft tissues and 59.8 cGy for bone. Imaging doses in correlation modeling were larger with RTTT. On a single 4D-CBCT, the skin and bone D2cc values were in the ranges of 7.4-10.5 cGy and 33.5-58.1 cGy, respectively. The D2cc from 4D-CBCT was approximately double that from 3D-CBCT. Clinicians should Figure that the imaging dose increases the cumulative doses to organs.

Database: Medline

5. Systematic intrafraction shifts of mediastinal lymph node targets between setup imaging and radiation treatment delivery in lung cancer patients.
**BACKGROUND AND PURPOSE:** Internal target motion results in geometrical uncertainties in lung cancer radiotherapy. In this study, we determined the intrafraction motion and baseline shifts of mediastinal lymph node (LN) targets between setup imaging and treatment delivery.

**MATERIAL AND METHOD:** Ten lung cancer patients with 2-4 fiducial markers implanted in LN targets received intensity-modulated radiotherapy with a daily setup cone-beam CT (CBCT) scan used for online soft-tissue match on the primary tumor. At a total of 122 fractions, 5 Hz fluoroscopic kV images were acquired orthogonal to the MV treatment beam during treatment delivery. Offline, the 3D trajectory of the markers was determined from their projected trajectory in the CBCT projections and in the intra-treatment kV images. Baseline shifts and changes in the respiratory motion amplitude between CBCT and treatment delivery were determined from the 3D trajectories.

**RESULT:** Systematic mean LN baseline shifts of 2.2 mm in the cranial direction (standard deviation (SD): 1.8 mm) and 1.0 mm in the posterior direction (SD: 1.2 mm) occurred between CBCT imaging and treatment delivery. The mean motion amplitudes during CBCT and treatment delivery agreed within 0.2 mm in all directions.

**CONCLUSION:** Systematic cranial and posterior intrafraction baseline shifts between CBCT and treatment delivery were observed for mediastinal LN targets. Intrafraction motion amplitudes were stable.

**Database:** Medline
projection correction and the SART reconstruction increased the accuracy of CBCT ventilation and this result can be a stepping stone to extract dynamic changes in respiration pattern of patients during radiotherapy.

**Database:** Medline

### 7. Prognostic Value of Primary Tumor Volume Changes on kV-CBCT during Definitive Chemoradiotherapy for Stage III Non-Small Cell Lung Cancer.

**Author(s):** Wald, Patrick; Mo, Xiaokui; Barney, Christian; Gunderson, Daniel; Haglund, A Karl; Bazan, Jose; Grecula, John; Chakravarti, Arnab; Williams, Terence; Carbone, David P; Xu-Welliver, Meng

**Source:** Journal of thoracic oncology : official publication of the International Association for the Study of Lung Cancer; Dec 2017; vol. 12 (no. 12); p. 1779-1787

**Publication Date:** Dec 2017

**Publication Type(s):** Journal Article

**PubMedID:** 28843360

**Abstract:** INTRODUCTION Kilovoltage cone beam computed tomography (kV-CBCT) allows for tumor localization and response assessment during definitive chemoradiotherapy for locally advanced NSCLC. We hypothesize that significant tumor volume loss occurs early during radiotherapy and that the extent of volume loss correlates with clinical outcomes. METHODS A total of 52 patients with locally advanced NSCLC treated with definitive chemoradiotherapy were reviewed. kV-CBCT images were used to contour primary gross tumor volumes at four time points during treatment. Patients were dichotomized according to absolute and relative volume changes at each time point. Statistical analyses were performed to evaluate correlations between volume changes and clinical outcomes. RESULTS The median gross tumor volumes were 77.1, 48.3, 42.5, and 29.9 cm³ for fractions 1, 11, 21, and final, respectively. Greater relative volume loss between fractions 1 and 21 correlated with improved distant control (hazard ratio [HR] = 0.35, 95% confidence interval [CI]: 0.13-0.94, p = 0.038) and overall survival (HR = 0.40, 95% CI: 0.16-0.98, p = 0.046). Greater relative volume loss between fractions 11 and 21 correlated with improved progression-free survival (HR = 0.39, 95% CI: 0.17-0.88, p = 0.02) and trended toward improved overall survival (HR = 0.43, 95% CI: 0.17-1.06, p = 0.07). On multivariate analysis, greater relative volume loss between fractions 11 and 21 correlated with improved progression-free survival (HR = 0.39, 95% CI: 0.16-0.97, p = 0.041) and overall survival (HR = 0.31, 95% CI: 0.11-0.88, p = 0.027). CONCLUSIONS Significant primary tumor volume loss occurs early during radiotherapy for locally advanced NSCLC. Greater relative tumor volume loss during treatment correlates with improved disease control and overall survival. Thus, kV-CBCT has potential to be used as a practical prognostic imaging marker.

**Database:** Medline

### 8. Potential for Intersession Motion to Increase Esophageal Toxicity in Lung SBRT

**Author(s):** Pham A.H.-N.; Yorke E.; Rimner A.; Wu A.J.-C.

**Source:** Technology in Cancer Research and Treatment; Dec 2017; vol. 16 (no. 6); p. 935-943

**Publication Date:** Dec 2017

**Publication Type(s):** Article

**Available at** [Technology in Cancer Research & Treatment](https://www.ncbi.nlm.nih.gov/pubmed/28843360) - from PubMed Central

**Abstract:** Purpose: To characterize the effect of the relative motion of esophagus and tumor on radiation doses to the esophagus in patients treated with stereotactic body radiation therapy for
central lung tumors. Methods and Materials: Fifty fractions of stereotactic body radiation therapy in 10 patients with lung tumors within 2.5 cm of the esophagus were reviewed. The esophagus was delineated on each treatment’s cone-beam computed tomography scan and compared to its position on the planning scan. Dose-volume histograms were calculated using the original treatment beams to determine the actual dose delivered to the esophagus for each fraction of stereotactic body radiation therapy. Results: Median interfraction right-left shift of the esophagus was 0.9 mm (range, -5.4 to 3.3 mm) toward the left. Median interfraction anteroposterior shift was 0.7 mm (range, -3.7 to 11.5 mm) posteriorly. The median percentage increase in dose to 1 cm³, dose to 3.5 cm³, and dose to 5 cm³ was 1.7%, 5.6%, and 6.6%, respectively. Two cases of significant late esophageal toxicity were observed, with change in esophageal position relative to the planning target volume resulting in significantly higher D5cc values than anticipated. Conclusion: Interfraction shifts between the internal target volume and esophagus can lead to unanticipated increases in the volume of esophagus receiving high doses when treating central lung tumors with stereotactic body radiation therapy. Certain practical steps, such as considering deep breath hold for internal target volume reduction, using a planning risk volume for esophagus, and carefully visualizing and considering esophageal position at the time of stereotactic body radiation therapy, can be taken to minimize unanticipated dose increases that could cause unexpected esophageal toxicity.

Database: EMBASE


Author(s): Tan, Zhibo; Liu, Chuanyao; Zhou, Ying; Shen, Weixi
Source: Journal of radiation research; Nov 2017; vol. 58 (no. 6); p. 854-861
Publication Date: Nov 2017
Publication Type(s): Journal Article
PubMedID: 28992047
Available at Journal of Radiation Research - from Oxford Journals - Open Access
Available at Journal of Radiation Research - from HighWire - Free Full Text
Available at Journal of Radiation Research - from Europe PubMed Central - Open Access
Available at Journal of Radiation Research - from PubMed Central

Abstract: In this study, we compared the registration effectiveness of 4D cone-beam computed tomography (CBCT) and 3D-CBCT for image-guided radiotherapy in 20 Stage IA non-small-cell lung cancer (NSCLC) patients. Patients underwent 4D-CBCT and 3D-CBCT immediately before radiotherapy, and the X-ray Volume Imaging software system was used for image registration. We performed automatic bone registration and soft tissue registration between 4D-CBCT or 3D-CBCT and 4D-CT images; the regions of interest (ROIs) were the vertebral body on the layer corresponding to the tumor and the internal target volume region. The relative displacement of the gross tumor volume between the 4D-CBCT end-expiratory phase sequence and 4D-CT was used to evaluate the registration error. Among the 20 patients (12 males, 8 females; 35-67 years old; median age, 52 years), 3 had central NSCLC and 17 had peripheral NSCLC, 8 in the upper or middle lobe and 12 in the lower lobe (maximum tumor diameter range, 18-27 mm). The internal motion range in three-dimensional space was 12.52 ± 2.65 mm, accounting for 47.8 ± 15.3% of the maximum diameter of each tumor. The errors of image-guided registration using 4D-CBCT and 3D-CBCT on the x (left-right), y (superior-inferior), z (anterior-posterior) axes, and 3D space were 0.80 ± 0.21 mm and 1.08 ± 0.25 mm, 2.02 ± 0.46 mm and 3.30 ± 0.53 mm, 0.52 ± 0.16 mm and 0.85 ± 0.24 mm, and 2.25 ± 0.44 mm and 3.59 ± 0.48 mm (all P < 0.001), respectively. Thus, 4D-CBCT is preferable to 3D-CBCT for image...
guidance in small pulmonary tumors because 4D-CBCT can reduce the uncertainty in the tumor location resulting from internal motion caused by respiratory movements, thereby increasing the image-guidance accuracy.

Database: Medline

10. Feature selection methodology for longitudinal cone-beam CT radiomics.

**Author(s):** van Timmeren, Janna E; Leijenaar, Ralph T H; van Elmpt, Wouter; Reymen, Bart; Lambin, Philippe

**Source:** Acta oncologica (Stockholm, Sweden); Nov 2017; vol. 56 (no. 11); p. 1537-1543

**Publication Date:** Nov 2017

**Publication Type(s):** Journal Article

**PubMedID:** 28826307

**Abstract:** BACKGROUND Cone-beam CT (CBCT) scans are typically acquired daily for positioning verification of non-small cell lung cancer (NSCLC) patients. Quantitative information, derived using radiomics, can potentially contribute to (early) treatment adaptation. The aims of this study were to (1) describe and investigate a methodology for feature selection of a longitudinal radiomics approach (2) investigate which time-point during treatment is potentially useful for early treatment response assessment.

**MATERIAL AND METHODS** For 90 NSCLC patients CBCT scans of the first two fractions of treatment (considered as 'test-retest' scans) were analyzed, as well as weekly CBCT images. One hundred and sixteen radiomic features were extracted from the GTV of all scans and subsequently absolute and relative differences were calculated between weekly CBCT images and the CBCT of the first fraction. Test-retest scans were used to determine the smallest detectable change ($C = 1.96 \times SD$) allowing for feature selection by choosing a minimum number of patients for which a feature should change more than 'C' to be considered as relevant. Analysis of which features change at which moment during treatment was used to investigate which time-point is potentially relevant to extract longitudinal radiomics information for early treatment response assessment.

**RESULTS** A total of six absolute delta features changed for at least ten patients at week 2 of treatment and increased to 61 at week 3, 79 at week 4 and 85 at week 5. There was 93% overlap between features selected at week 3 and the other weeks.

**CONCLUSION** This study describes a feature selection methodology for longitudinal radiomics that is able to select reproducible delta radiomics features that are informative due to their change during treatment, which can potentially be used for treatment decisions concerning adaptive radiotherapy. Nonetheless, the prognostic value of the selected delta radiomic features should be investigated in future studies.

Database: Medline

11. Local recurrence rate and timing after stereotactic body radiotherapy for lung cancer: Need for longterm follow-up

**Author(s):** Shintani T.; Matsuo Y.; Mitsuyoshi T.; Iizuka Y.; Mizowaki T.

**Source:** Journal of Thoracic Oncology; Nov 2017; vol. 12 (no. 11)

**Publication Date:** Nov 2017

**Publication Type(s):** Conference Abstract

**Abstract:** Background: Local control rate by stereotactic body radiotherapy (SBRT) for stage I non-small cell lung cancer (NSCLC) has been reported to be approximately 90%. But, most studies had relatively short follow-up time, and our group has previously published preliminary report that late
local recurrence (LR) might not be negligible. Thus, the aim of this study was to assess LR rate and timing after SBRT, using long-term follow-up data of large cohorts from single institution. Method: Eligible patients were those who were treated with SBRT (isocenter prescription of 48Gy/4fr) between April 1998 and August 2014 for primary/recurrent NSCLC <5cm and with >6 months follow-up time. Result: A total of 213 patients (229 tumors) were analyzed. Tumor and treatment characteristics are shown in Table. Median follow-up time was 7 years [95% confidence interval (CI) 6.2-7.8]. 5-year overall survival and progression-free survival rate was 47%[95% CI 40-54] and 32% [95% CI 26-39], respectively. The number of LR was 45, and 5- and 10-year cumulative incidence of LR was 18%[95% CI 13-23] and 26%[95% CI 18-33], respectively. Clinical T stage, histology, tumor location, overall treatment time and use of cone-beam CT for patient set-up did not impact LR rate, as shown in Table. Median time to LR was 1.7 years (range: 0.6-9.5, interquartile range: 1.0-3.2) and time to LR was significantly longer in adenocarcinoma (Adeno) than in squamous cell carcinoma (SqCC) (median: 2.7 vs. 1.1 years, p=0.04). The number of late LR >5 years after SBRT was six. The histology of tumors with late LR was Adeno/SqCC/unknown=3/1/2 (one of two unknown cases was proven to be Adeno by salvage surgery). Five of six late LRs were isolated LR as the first progression site. Conclusion: Late LR was not uncommon. Long-term follow-up after SBRT is needed, especially for adenocarcinoma. (Figure Presented).

Database: EMBASE

12. No differences in radiological changes after 3D conformal vs VMAT-based stereotactic radiotherapy for early stage non-small cell lung cancer.

Author(s): Badellino, Serena; Muzio, Jacopo Di; Schizavappa, Giulia; Guarneri, Alessia; Ragona, Riccardo; Bartoncini, Sara; Trino, Elisabetta; Filippi, Andrea Riccardo; Fonio, Paolo; Ricardi, Umberto

Source: The British journal of radiology; Oct 2017; vol. 90 (no. 1078); p. 20170143

Publication Date: Oct 2017

Publication Type(s): Comparative Study Journal Article

PubMedID: 28749172

Abstract:OBJECTIVETo compare patterns of acute and late radiological lung injury following either 3D conformal or image-guided volumetric modulated arc therapy stereotactic radiotherapy for Stage I non-small-cell lung cancer.METHODSWe included 148 patients from a prospective mono-institutional stereotactic body radiation therapy (SBRT) series (time interval 2004-2014), treated with prescription BED10 Gy (at 80%) in the range 100-120 Gy. The first 95 patients (2004-2010) were planned with 3D-CRT, with a stereotactic body frame. The second cohort (2010-2014) included 53 patients, planned with volumetric IMRT on a smaller planning target volume generated from a patient’s specific internal target volume, with a frameless approach through cone-beam CT guidance. Acute and late radiological modifications were scored based on modified Kimura’s and Koenig’s classifications, respectively.RESULTSMedian follow-up time was 20.5 months. The incidence of acute radiological changes was superimposable between the groups: increased density was observed in 68.4 and 64.2% of patients for 3D-CRT and VMAT, respectively, and patchy ground glass opacity in 23.7 and 24.5%, respectively; diffuse ground glass opacity was 2.6 vs 9.4%, respectively, and patchy consolidation 2.6 vs 1.9%, respectively. Late changes occurred in approximately 60% of patients: modified conventional pattern was the most frequent modification (25 vs 32.6%, respectively); other patterns were less common (mass-like 19.6 vs 17.4%, and scar-like 13 vs 10.9%, respectively).CONCLUSIONResults of the present study indicate that the pattern of radiological lung changes following SBRT for peripheral early stage non-small-cell lung cancer is not influenced by the different techniques used for planning and delivery. Advances in knowledge: This comparative observational study shows that smaller margins, image guidance and most importantly dose
distribution do not change the pattern of radiological injury after lung SBRT; the same scoring system can be used, and expected incidence is similar.

**Database:** Medline

### 13. Interobserver variability of patient positioning using four different CT datasets for image registration in lung stereotactic body radiotherapy.

**Author(s):** Oechsner, Markus; Chizzali, Barbara; Devecka, Michal; Münch, Stefan; Combs, Stephanie Elisabeth; Wilkens, Jan Jakob; Duma, Marciana Nona

**Source:** Strahlentherapie und Onkologie : Organ der Deutschen Rontgengesellschaft ... [et al]; Oct 2017; vol. 193 (no. 10); p. 831-839

**Publication Date:** Oct 2017

**Publication Type(s):** Journal Article

**PubMedID:** 28726056

**Abstract:** PURPOSE: To assess the impact of different reference CT datasets on manual image registration with free-breathing three-dimensional (3D) cone beam CTs (FB-CBCT) for patient positioning by several observers. METHODS: For 48 patients with lung lesions, manual image registration with FB-CBCTs was performed by four observers. A slow planning CT (PCT), average intensity projection (AIP), maximum intensity projection (MIP), and midventilation CT (MidV) were used as reference images. Couch shift differences between the four reference CT datasets for each observer as well as shift differences between the observers for the same reference CT dataset were determined. Statistical analyses were performed and correlations between the registration differences and the 3D tumor motion and the CBCT score were calculated. RESULTS: The mean 3D shift difference between different reference CT datasets was the smallest for AIP vs MIP (range 1.1-2.2 mm) and the largest for MidV vs PCT (2.8-3.5 mm) with differences >10 mm. The 3D shifts showed partially significant correlations to 3D tumor motion and CBCT score. The interobserver comparison for the same reference CTs resulted in the smallest Δ3D mean differences and mean Δ3D standard deviation for ΔAIP (1.5 ± 0.7 mm, 0.7 ± 0.4 mm). The maximal 3D shift difference between observers was 10.4 mm (ΔMidV). Both 3D tumor motion and mean CBCT score correlated with the shift differences (Rs = 0.336-0.740). CONCLUSION: The applied reference CT dataset impacts image registration and causes interobserver variabilities. The 3D tumor motion and CBCT quality affect shift differences. The smallest differences were found for AIP which might be the most appropriate CT dataset for image registration with FB-CBCT.

**Database:** Medline

### 14. Cbct-derived radiosensitivity marker associated with radiation pneumonitis

**Author(s):** Lang P.; Moseley D.J.; Bernchou U.; Brink C.; Hope A.J.

**Source:** International Journal of Radiation Oncology Biology Physics; Oct 2017; vol. 99 (no. 2)

**Publication Date:** Oct 2017

**Publication Type(s):** Conference Abstract

**Available at:** International Journal of Radiation Oncology*Biology*Physics - from ScienceDirect

**Abstract:** Purpose/Objective(s): Dose escalation of non-small cell lung cancer is limited by increasing risk of severe adverse events, including radiation pneumonitis (RP). Recent studies have demonstrated a relationship between a cone beam computed tomography (CBCT) derived marker (CDM) and lung density changes on follow-up imaging. This study investigates the relationship...
between the CDM and symptomatic radiation pneumonitis in a new dataset. Purpose/Objective(s): The CDM was defined as the proportion of normal lung tissue voxels receiving > 20 Gy that demonstrated an intensity increase beyond an expected noise threshold as previously described in [Radiother Oncol 2015;117:17-22]. CDMs were defined for both the tenth (CDM10) and twentieth (CDM20) fractions. CDMs were extracted for NSCLC patients treated definitively (>54 Gy) with fractionated (1.8-2 Gy/fraction) radiotherapy at the Princess Margaret Cancer Centre between 2011 and 2015. The exclusion criteria included patients without CBCT or dose objects available for analysis, patients receiving neoadjuvant radiotherapy, patients with previous radiation treatment in the thorax, and patients who had an in-thorax recurrence or were lost to follow-up within 1 year without evidence of pneumonitis. Images were registered into a common volume using an intensity-based deformable image registration algorithm in the Elastix toolbox. Image registration accuracy was manually checked. All other image analysis was implemented in Matlab 2013. RP was determined from prospective clinical records scored by the treating oncologists at follow-up visits as per CTCAE v 4.0, and reviewed retrospectively. Correlation of dosimetric parameters (mean lung dose (MLD), V20) and the CDMs to RP events was assessed by logistical regression. Results: Fourteen percent of patients had image registration failure due to large deformations. CDMs were extracted in the remaining 84 patients. The prescription dose range was 54-74 Gy, mean lung dose range was 2.2-26 Gy and V20 range was 3.4-36%. Fifty-four percent of patients had concurrent chemotherapy with cisplatin or carboplatin and etoposide. Symptomatic RP (>= Grade 2) occurred in 26.1% of patients of these patients. Univariate logistic regression of the CDM20 was significantly correlated with symptomatic RP (P < 0.01), while MLD, V20 and CDM10 were not significantly correlated. Multivariate logistical regression with CDM20 and V20 was significant for both (P < 0.05).

Conclusion: This study suggests a relationship exists between symptomatic RP and a CBCT response marker initially derived to predict density changes in follow-up images. CBCT is regularly acquired as part of routine clinical care, and a CBCT derived marker may allow for modifications to treatment including reductions in dose, closer monitoring, and earlier initiation of steroid treatment. Future work is needed to improve the CBCT image quality and the deformable image registration accuracy.

Database: EMBASE

15. Comparison of lung tumor volume reduction rates measured by cone beam computed tomography across different fractionation schedules

Author(s): Choi S.; Wahl M.; Braunstein S.E.

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Publication Type(s): Conference Abstract

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Abstract: Purpose/Objective(s): Previous studies have shown that tumor volume reduction measured by weekly cone beam computer tomography (CBCT) during chemoradiation for unresectable non-small cell lung cancer is associated with longer overall survival of unresectable non-small cell lung cancer patients, highlighting the power of CBCT information as a tool to predict response to radiotherapy. In this study, we sought to determine how tumor volume reduction rates measured on CBCT vary with the various radiation fractionation schedules used at our institution to treat lung tumors. Purpose/Objective(s): The records of 30 patients who received external beam radiation therapy with measurable lesions on daily CBCTs from 2012-2016 were retrospectively reviewed (n=30). Patient age, sex, tumor histology, tumor size, tumor location, radiation fractionation regimen, use of concurrent chemotherapy and survival post-radiation were recorded. The lung tumor volumes on CBCT were measured using contouring software for treatment days spaced 7 days
The percent total tumor volume (TV) reduction was calculated from baseline to the last day of treatment using the formula: \(100 \times \frac{TV_{CBCT_{start}} - TV_{CBCT_{end}}}{TV_{CBC_{start}}}\). The early percent TV reduction was calculated using the formula: \(100 \times \frac{TV_{CBCT_{start}} - TV_{CBCT_{day7}}}{TV_{CBC_{start}}}\). Tumor BED was calculated using \(\alpha/\beta=10\). Results: Of the 30 patients in the study, 70% had adenocarcinoma and 30% had squamous cell carcinoma histologies. Ten different fractionation schedules were used: 66 Gy/33 fx (n=2), 66 Gy/30 fx (n=5), 63 Gy/35 fx (n=3), 60 Gy/30 fx (n=9), 60 Gy/24 fx (n=1), 60 Gy/15 fx (n=1), 48.6 Gy/27 fx (n=1), 45 Gy/25 fx (n=3), 45 Gy/15 fx (n=3), 40 Gy/15 fx (n=2). The median initial tumor volume was 50.47 cc (range: 3.82 to 350.75 cc). The mean total tumor volume reductions and mean early TV reduction per fractionation group (with n>3) were: 42.8% and 10.2% for 66 Gy/30 fx (BED=85.8); 49.6% and 22.7% for 66 Gy/30 fx (BED=80.5); 43.4% and 3.9% for 63 Gy/35 fx (BED=74.34); 39.1% and 10.3% for 60 Gy/30 fx (BED=72); 38.4% and 12.3% for 45 Gy/15 fx (BED=58.5); and 51.9% and 13.7% for 45 Gy/25 fx (BED=53.1). There was no correlation between BED and total or early TV reduction (\(r=-0.12, p=0.8\) and \(r=0.03, p=0.9\)). Conclusion: Lung tumor volume reduction rates both early and at the end of treatment can be tracked using CBCT. The mean tumor volume reductions and mean early TV reduction vary among different fractionation groups. In the cohort of 30 patients, no correlation was detected between BED and total or early TV reduction (\(r=-0.12, p=0.8\) and \(r=0.03, p=0.9\)). Ongoing are analyses on additional patients to detect whether a statistically significant difference can be detected between tumor volume reduction rates per fractionation scheme.

**Database:** EMBASE

### 16. Imaging-based outcomes for 24 gy in 2 daily fractions for patients with de novo spinal metastases treated with spine stereotactic body radiation therapy: An emerging standard

**Author(s):** Tseng C.L.; Campbell M.; Soliman H.; Myrehaug S.; Sahgal A.; Ruschin M.E.; Lee Y.; Atenafu E.

**Source:** International Journal of Radiation Oncology Biology Physics; Oct 2017; vol. 99 (no. 2)

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**Publication Type(s):** Conference Abstract

Available at [International Journal of Radiation Oncology Biology Physics](https://www.sciencedirect.com/science/article/pii/S0360301617302411) from ScienceDirect

**Abstract:** Purpose/Objective(s): Currently, there is no consensus fractionation scheme for spine SBRT. We report mature outcomes for a cohort of patients with no prior radiation (de novo) treated with 24 Gy in 2 daily fractions, which represents an emerging Canadian standard. Purpose/Objective(s): The cohort consisted of 279 de novo spinal metastases in 145 consecutive patients treated with 24 Gy in 2 SBRT fractions, between 2009 and 2015, identified from a prospective database. All vertebral segments were treated with an institutionally standardized Linac-based approach using cone-beam CT image guidance and six degrees-of-freedom online setup correction. The endpoints were overall survival (OS), local control (LC), and the rate of vertebral compression fractures (VCF). OS rates were obtained using Kaplan-Meier methods and cumulative incidences of LC and VCF were obtained from competing risk analysis using death as a competing risk event. Evaluation of tumor control was based on serial spine magnetic resonance imaging (MRI) as per the SPIne response assessment in Neuro-Oncology (SPINO) criteria recommendations. Results: The median follow-up was 17.0 months (range, 0.1-71.6 months). The 1-year and 2-year OS rates were 73.1% and 60.7%, respectively. Presence of epidural disease (P < 0.0001), lung (P = 0.0415) and renal cell (P < 0.0001) primary histologies and diffuse spinal metastatic disease as opposed to oligometastatic disease (P = 0.0034) were significant prognostic factors. The 1-year and 2-year LC rates were 90.3% and 82.4%, respectively, and the median time to local failure (LF) was 9.2 month (range, 0.4-31.3 months). Only the presence of epidural disease predicted for LF (P < 0.0001). The
cumulative risk of VCF at 1 and 2 years were 8.5% and 13.8%, respectively. Lytic (P = 0.0143) or mixed lytic/blastic (P = 0.0214) lesions, spinal misalignment (P = 0.0121), and the dose to 90% of the planning target volume (PTVD90) (P = 0.0085) were significant predictors of VCF. Conclusion: Twenty-four Gy in 2 daily fractions is safe and effective in achieving high tumor control rates for de novo spinal metastases. This fractionation scheme is currently the standard SBRT arm on an ongoing Phase 3 randomized Canadian national trial (CCTG-SC 24) comparing it to a conventional radiation dose of 20 Gy delivered in 5 daily fractions.

**Database:** EMBASE

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17. Evaluation of gross tumor volume changes prior to the first delivered fraction in primary and metastatic lung tumors treated by stereotactic body radiation therapy: Does time from simulation to start matter?

**Author(s):** King S.; Sood S.S.; Tennapel M.J.; Aguilera N.; Wang F.; Chen A.M.; Badkul R.K.

**Source:** International Journal of Radiation Oncology Biology Physics; Oct 2017; vol. 99 (no. 2)

**Publication Date:** Oct 2017

**Publication Type(s):** Conference Abstract

**Abstract:** Purpose/Objective(s): To quantitate potential volumetric discrepancies in gross tumor volume (GTV) from time of simulation to the delivery of the first radiation fraction and to identify predictors of size change for patients with primary and metastatic lung tumors treated by image-guided stereotactic body radiotherapy (SBRT). Purpose/Objective(s): The cone beam computed tomography (CBCT) scan obtained at the first fraction of radiation for 14 primary early-stage non-small cell lung cancer tumors and 10 metastatic lung tumors treated with thoracic SBRT were rigidly registered to the initial computed tomography (CT) scans obtained at simulation. All patients were treated with four-dimensional CT (4DCT)-based image-guided 3-5 fraction SBRT using abdominal compression and body-fixation. The GTV was delineated on both the mean intensity projection (MeanIP) data set of the CT simulation scan and the CBCT scan, and percent change in GTV volume was calculated from time of CT simulation to first fraction of treatment. The most common prescription dose and fractionation regimen was 50 Gy in 5 fractions (n = 21). The fraction size ranged from 8 to 18 Gy (median, 10 Gy). The correlation between percentage GTV change and treatment variables, tumor characteristics, and clinical outcome (median 45 months, range 25 to 77 months) were statistically evaluated using linear regression to test significance. Results: The median patient age was 72 years (range, 43 to 90 years). GTV and planning target volume (PTV) were 7.8 cc (range, 0.8 to 53.8 cc), and 31.2 cc (range, 7.5 to 118.2 cc), respectively. For all treated tumors, GTV increased a median of 19.9% (range, -4.4 to 45.9%) over a median time interval of 13 days (range, 2 to 39 days). When stratified according to tumor status, primary lung tumors exhibited a median percent GTV change of 16.2% (range,-4.4 to 39.49%), and metastatic lung tumors GTV size increased a median of 23.4% (range,-3.7 to 45.9 %). The degree of percentage GTV change was inversely related to initial tumor volume on CBCT scan for all treated tumors (P = 0.004). The observed change in GTV volume and treatment interval for all tumors approached significance (P = 0.07) with tumors treated less than or equal to 10 days exhibiting smaller % change in volume compared to those treated after 10 days. Right sided lung tumors were more likely to experience increase in GTV size (P = 0.03). Primary vs. metastatic status, histology, and central vs. peripheral tumor location did not correlate with observed tumor volume change (P > 0.05). Degree of GTV change did not correlate with clinically observed local control rates (P > 0.05). Conclusion: Target localization during SBRT is critical, and our results emphasize the value for accurate image guidance techniques for all thoracic tumors treated with hypofractionated courses, particularly in smaller tumors in which larger changes
gross tumor volume may be observed. Decreasing time interval from CT simulation to first fraction to 10 days or less may minimize the degree of volumetric tumor change.

**Database:** EMBASE

### 18. Operable stage I non-small cell lung cancer treated with stereotactic radiotherapy (SBRT) compared to surgical lobectomy: Failure patterns and implications for management

**Author(s):** Grills I.S.; Lee K.C.; Hymas R.V.; Ye H.; Sura K.; Johnson M.C.; Abro N.; Caruso A.; Abbott E.; Deraniyagala R.L.; Stevens C.W.; Welsh R.

**Source:** International Journal of Radiation Oncology Biology Physics; Oct 2017; vol. 99 (no. 2)

**Publication Date:** Oct 2017

**Publication Type(s):** Conference Abstract

**Abstract:**
Purpose/Objective(s): Compare outcomes for biopsy-proven operable NSCLC treated with SBRT or standard of care lobectomy. Purpose/Objective(s): Two hundred fifty-four patients with Stage I T1-2N0M0 NSCLC medically operable for resection underwent cone-beam CT image-guided SBRT to a median dose of 48 Gy/4 fractions (48-60 Gy; 3-5) (n = 32), 29/32 on a prospective clinical trial allowing patients refusing surgery (n = 32) OR Lobectomy (L) (n = 222) at a single institution. Median age was 73y for SBRT v 69 for L (P = 0.002). The following were similar between groups for SBRT vs L: median tumor size 2.2 vs 2.2 cm, median baseline max SUV 5.3 vs 6.0, gender 63% vs 59% female, T stage 75% vs 69% T1, synchronous lung cancer 6% vs 7%, smoking history 88% v 86%, and receipt of chemotherapy 9% v 16% (P = NS). SBRT group had more squamous cell ca (32% vs 5%, P=0.001), more prior lung cancer (25% v 1%, P<0.001), and lower PFT (median FEV1 1.4L vs 1.9L, %predFEV1 52% vs 79%, DLCO 10.6 vs 16.3, %pred DLCO 37% vs 72%, P<0.01). Mediastinoscopy was done in 19% of SBRT cases; all L cases had nodal staging. From these, a propensity match was performed using: age, gender, tumor size, prior/synchronous lung cancer, baseline SUV, and FEV1 yielding 14 pairs. Imbalanced factors remained %pred DLCO (46% vs 62%, P = 0.018), LN sampling (30% for SBRT) and histology. Survival/recurrence was calculated according to Kaplan Meier. Median follow-up time was 5.8 years for all cases. Results: The 2-year, 3-year, and 5-year outcomes in Table 1. SBRT had higher rates of regional recurrence (RR), and clinical failure (CF). SBRT and L had similar local recurrence (LR) and distant metastasis (DM). L had higher overall survival (OS) and disease-free survival (DFS), with a P = 0.012 for cause-specific survival. For the matched group, SBRT had higher CF, lower DFS, and OS, with 5y LR (11% v 7%), RR 16% v 8%, and DM 21% v 15%. Baseline SUV, squamous histology, and metachronous ca predicted LR on UVA; all 3 remained significant on MVA (squamous histology HR 12.2). Significant factors predicting RR on UVA were squamous histology (P = 0.017, Hazard Ratio 6.1) and L v SBRT (P = 0.01, L HR 0.26) with the latter true on MVA. Tumor max dimension and baseline SUV were highly correlated and predicted DM, along with chemotherapy. SUV and chemo remained on MVA. Conclusion: SBRT in this operable population had similar rates of LR but higher rates of RR and CF and lower DFS and OS compared to lobectomy. Although operable, SBRT served as a second curative therapy for a new lung cancer in 25% of the applied population. Squamous histology serves as a predictor of not only LR but RR after SBRT, implying employment of more rigorous staging and further radiobiological evaluation.

**Database:** EMBASE

### 19. Interfraction tumor size changes during lung SBRT: What factors matter?

**Author(s):** King K.; Mayekar S.; Tolekidis G.; Marwaha G.; Cifter G.; Zhen H.
Purpose/Objective(s): Prior studies have suggested that lung stereotactic body radiation therapy (SBRT) can cause volumetric tumor size changes on setup imaging during treatment, however predictors for such changes have not been well described. With the advent of kilovoltage (kv) cone beam computed tomography (CBCT) scans in the SBRT setup process, visualization of tumor changes are more readily apparent. The purpose of this study was to evaluate the role played by patient, tumor, and dosimetric factors in the interfraction tumor changes seen in our lung SBRT patient population. Purpose/Objective(s): A retrospective chart review was conducted on forty consecutive patients from our IRB-approved lung SBRT database treated between 2014-2016. Each patient was set up under daily stereoscopic X-ray and kv CBCT guidance. A single radiation oncologist retrospectively re-contoured the tumor volume on each sequential kv CBCT image to determine volumetric variances. A univariate and multivariate analysis with a linear model were employed in SPSS R 3.3.1. Results: Forty patients with either squamous cell carcinoma (12.5%), adenocarcinoma (52.5%), or metastatic renal cell carcinoma (5%) of the lung were identified. 20 (50%) patients received an SBRT dose of 54 Gy/3 fx and 20 (50%) patients received 50-60 Gy/5 fx. 8 (20%) of the tumors were centrally located (by the RTOG 0813 definition) while 32 (80%) were peripheral. Six (15%) of the patients had never smoked while 28 (78%) were former smokers and 6 (15%) continued to smoke during their treatment. The median pretreatment neutrophil lymphocyte ratio (NLR) was 3.03 (range: 0.09-67.21) and the median post-treatment NLR was 2.74 (range: 0.17-12.59). Within the 3 fraction group, there was a median decrease in tumor size of 10% between the first and third fractions; within the 5 fraction group, a total decrease in tumor size of 4% was observed between the first and the fifth fractions. On univariate analysis, only location (p=0.0843), dose (p=0.0881), and histology (p=0.0903) correlated with interfraction tumor size reduction. On multivariate analysis, only adenocarcinoma histology (p=0.0736) and renal cell carcinoma histology (p=0.0221) remained statistically significant. Conclusion: In this study, we observed interfraction changes in tumor volume in patients treated with SBRT. Of all the patient, tumor, and dosimetric factors analyzed, histology was the only factor to significantly correlate with interfraction tumor size changes. Further lung SBRT interfraction volumetric studies are needed to better characterize which types of patients/tumors experience which type of changes. This may play a role in optimizing setup imaging further and/or individually tailoring planning treatment volumes moving forward.

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change. In this study, deformable registration (DIR) and dose accumulation (DA) were used to calculate the dose delivered over the course of treatment. These delivered doses were then compared with the clinical treatment plan. Purpose/Objective(s): This single institution, retrospective study selected 26 sequential patients diagnosed with LA-NSCLC receiving radical chemo-radiotherapy. Using RayStation 4.5.2, doses were calculated on daily cone-beam CT images acquired for daily verification were then deformed and mapped back onto the planning CT images. DA results were compared to the clinical treatment plan for both target coverage and organs at risk.

Results: Findings are summarized in Table 1. On average, DA calculations were not statistically different from the clinical plan (p<0.05). The DA to the clinical target volumes for both targets (CTV-T) and nodes (CTV-N) demonstrated that coverage remained close to that planned. The DA for OARs was also maintained as compared to the clinical plan. While, on average, delivered doses remained within our routine clinical tolerances, outliers were observed. DA for each patient indicated a small decrease of the delivered dose with respect to their clinical plan, although large variations were observed for organs at risk. Conclusion: We successfully demonstrated that DIR and DA can assess delivered doses to patients receiving radiotherapy for LA-NSCLC. We have confirmed that, on average, our PTV margins are adequate and robust from a dosimetric perspective. Given our LA-NSCLC sample, our results may not be representative Non-Small Cell (NSCLC) population. Although no average differences seen, outliers persist and will be the focus of future research.

Database: EMBASE

21. The value of cbct-based tumor volume and density variations in prediction of early response to chemoradiation therapy in advanced NSCLC

Author(s): Wen Q.; Meng X.; Sun X.; Zhu J.; Ma C.; Bai T.; Yu J.

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Publication Date: Oct 2017

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Abstract:Purpose/Objective(s): To investigate the correlations between physical density changes and primary tumor volume (TV) variations by kilovoltage cone-beam computed tomography (KV-CBCT). The second aim is to assess whether these could be valuable to predict chemoradiation therapy (CRT) response in non-small cell lung cancer (NSCLC) patients. Purpose/Objective(s): Fifty-four patients with inoperable and locally advanced NSCLC who received CRT and CBCT were involved in this study. Primary tumor were manually delineated on CBCT images on 1st, 6th, 11th, 16th, 21st, 26th, and 32nd fractions through 3D Slicer. TV and CT numbers (CTN) were measured on each of the seven observation points by IBEX. Variation ratios of TV (cm3) and CTN mean values (Hu) during the treatment course were analyzed and correlated with clinical outcomes evaluated by RECIST criteria. Pearson test was used for correlation analysis, t-test, and ROC curve were applied to assess the prediction abilities of CTN and TV for CRT outcomes. Results: TV reduction was observed in primary tumors for all patients from Day 1 (D1) to Day 32 (D32) CBCTs with a median shrinkage ratio of 28.28% (-15.57%-61.67%) and CTN was reduced with a mean value of 24.91+/-.12.34 Hu over the radiotherapy course. The change of CTN was linearly correlated with radiation doses (mean R2 = 0.889 +/- 0.164), while the correlation between CTN changes and TV reduction ratio was weaker (R2 = 0.257). For patients with response, the TV and CTN reduced by 32.01% (8.46%-61.67%) and 28.44+/-.13.12 Hu, which were significantly higher than those in the non-response patients with 23.20% (-15.57%-38%) and 19.63+/-.8.67 Hu (P = 0.026 and P = 0.005), respectively. ROC curve illustrated that both TV shrinkage ratio (AUC = 0.693, P = 0.016) and CTN variation (AUC = 0.666, P = 0.037) could predict treatment response. The area under curve for combination of TV and CTN was
larger than any one alone (AUC = 0.751, P = 0.002). TV reduction during the period of D6-D11 (AUC = 0.667, P = 0.036) and CTN changes between D11 and D16 (AUC = 0.753, P = 0.002) demonstrated significance difference between response and non-response. Conclusion: For NSCLC tumor target, CTN variation was linearly correlated with the radiation dose received. The changes of TV and CTN obtained from CBCT images have the potential capability to predict early response of NSCLC, which could be able to identify NSCLC patients who benefit from CRT. The prediction capability may be improved by the combination of the changes on TV and CTN.

**Database:** EMBASE

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22. **Outcomes for image-guided frameless linear accelerator-based hypofractionated stereotactic radiotherapy in 5 daily fractions to the surgical cavity after resection of brain metastases**

**Author(s):** Soliman H.; Myrehaug S.; Tsao M.; Tseng C.L.; Sahgal A.; Hashmi A.H.; Ruschin M.E.; Lee Y.

**Source:** International Journal of Radiation Oncology Biology Physics; Oct 2017; vol. 99 (no. 2)

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**Available at:** International Journal of Radiation Oncology*Biology*Physics - from ScienceDirect

**Abstract:** Purpose/Objective(s): Cavity radiotherapy is an emerging option for post-operative treatment to the surgical bed after resection of brain metastases. We report our outcomes of a 5 daily hypofractionated image-guided multi-leaf collimator linear accelerator (LINAC)-based stereotactic radiation (HSRT) to the surgical cavity. Purpose/Objective(s): Patients with brain metastases identified from a prospective institutional registry treated with HSRT, between Oct 2009-Dec 2014, were reviewed. A thermoplastic mask in a LINAC equipped with a cone-beam CT and a six-degrees-of-freedom treatment couch was used for treatment. Local brain control (LC) was determined with Fine and Gray's competing risk method with death as the competing risk. Overall survival (OS) and progression free survival (PFS) rates were calculated using the Kaplan-Meier method. Patterns of brain recurrence and risk of radiation necrosis were also determined. Results: 122 patients with a median follow-up of 12 months, treated most commonly with 30Gy in 5 fractions (75%), were analyzed. Non-small cell lung cancer was the most common histology (44%) followed by breast cancer (20%) and renal cell cancer (8%). 86% of patients had no prior brain radiation. The median tumour diameter was 3.3cm. The LC rates at 6 months, 12 months and 24 months were 91%, 84% and 74%, respectively. The PFS rates at 6 months, 12 months and 24 months were 78%, 55%, and 30%, respectively. The OS rates at 6 months, 12 months and 24 months were 86%, 62% and 37%, respectively. The 12 month rate for leptomeningeal recurrence was 22%. Colorectal histology was a negative predictor of local control (HR=4.1, p=0.007). Breast cancer histology (HR 2.1, p=0.05) and sub-total resection of the tumour (HR2.6, p=0.009) were predictors of leptomeningeal disease. Further treatment to the brain with radiation was delivered in 63 patients (46%) of which 46 patients (34%) received whole brain radiotherapy. Symptomatic radiation necrosis was observed in 7 patients (6%). Conclusion: HSRT with a daily 5 fraction regimen is a safe and effective treatment to the surgical bed after resection of brain metastases. Patients with breast cancer and a sub-total resection were at highest risk of subsequent leptomeningeal progression.

**Database:** EMBASE

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23. **Use of 3D optical surface mapping for quantification of interfraction set up error and intrafraction motion during stereotactic body radiation therapy treatments of the lung and abdomen**
Purpose/Objective(s): OSMS followed by IGRT with cone-beam computed tomography (CBCT) is used in our clinic as a standard technique for initial setup of patients (pts) receiving SBRT. OSMS is also utilized for continuous monitoring during treatment to detect intrafraction motion during SBRT. The purpose of this study is to analyze daily patient shift "deltas" determined during the initial phase of the IGRT process to assess the accuracy of OSMS at limiting interfraction patient set up error during SBRT and to measure the reliability of OSMS in detection and quantification of intrafraction motion for SBRT treatments of the lung and abdomen. Purpose/Objective(s): An IRB approved retrospective chart review was conducted to evaluate IGRT shift information for 58 pts with malignant thoracic or abdominal tumors treated with SBRT. A 2-step IGRT procedure was used for all reviewed therapy fractions-an initial setup using OSMS followed by CBCT for more accurate soft tissue and tumor volumetric localization. The "delta", represented by the additional CBCT translational and rotational shift measurements after initial setup from each treatment was recorded to assess interfraction setup error. After a new reference image was captured, pts were then monitored continuously with OSMS during treatment. If an intrafractional shift in any direction >2mm for longer than 2 seconds was detected by OSMS, then the treatment was stopped, and CBCT was repeated and the recorded deltas were compared to those detected by OSMS. A paired t-test was used to compare the difference in vector delta between the methods and considered significant if the p-value was less than alpha = 0.05. Results: 58 pts were identified with 71 lesions. The majority of lesions were located in the lung. Additional interfractional deltas after OSMS setup and soft tissue match with CBCT were small in all directions with mean values of 0.29 cm vertically, 0.41 cm in the longitudinally, 0.22 cm laterally, 0.44 degrees pitch, 0.40 degrees roll, and 0.39 degrees rotation. Additionally, 13 pts had intrafraction deltas during treatment detected with OSMS where repeat CBCT was performed. This resulted in 11 (84.6%) clinically meaningful additional shifts of at least 2 mm on subsequent CBCT. When comparing the vector delta for each method, no significant difference was found between the average delta detected by OSMS and the average delta detected by CBCT (0.30 cm versus 0.32 cm, p=0.608). Conclusion: OSMS provides a means of ensuring accurate initial setup of SBRT prior to volumetric IGRT with limited additional interfractional shifts. In addition, continuous monitoring with OSMS during treatment was valuable in detecting potentially clinically meaningful intrafraction motion and was comparable in magnitude to additional CBCT imaging suggesting good correlation. Additional data is being acquired to provide correlative statistics for detected intrafraction motion in each direction.

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24. Tumor volume dynamics on kV-CBCT during definitive radiation therapy for locally advanced NSCLC: Implications for prognosis and adaptive radiation therapy

Author(s): Wald P.M.; Barney C.; Grecura J.C.; Williams T.M.; Haglund K.E.; Bazan J.G.; Welliver M.X.; Mo X.

Source: International Journal of Radiation Oncology Biology Physics; Oct 2017; vol. 99 (no. 2)

Publication Date: Oct 2017

Publication Type(s): Conference Abstract
Abstract:Purpose/Objective(s): Standard treatment for locally advanced non-small cell lung cancer (LA-NSCLC) is concurrent chemoradiotherapy (CRT). Locoregional control (LRC) and overall survival (OS) are unacceptably low. However, prior dose escalation studies have failed to demonstrate a benefit with higher radiation doses, possibly secondary to increased normal tissue toxicity. Kilo-voltage cone beam computed tomography (kV-CBCT) provides an opportunity to assess tumor response during treatment, and substantial tumor shrinkage would suggest a potential advantage to adaptive radiotherapy. We hypothesize that significant tumor volume loss occurs early during radiotherapy and the extent of volume change correlates with LRC, progression-free survival (PFS), and OS. Purpose/Objective(s): Fifty-two consecutive patients with LA-NSCLC were treated with definitive chemoradiotherapy at our institution. All patients were treated on linear accelerators equipped with kV-CBCT on board imaging. kV-CBCT images were used to contour primary gross tumor volumes (GTV-P) at four time points during treatment (fractions 1, 11, 21, and final). Nodal GTVs were not included due to inability to reliably delineate on kV-CBCT. Absolute and relative volume changes were calculated at each time point. Each absolute and relative volume change parameter was dichotomized based on the median for the cohort. Univariate (UVA) and multivariate (MVA) analyses were performed to determine if absolute and/or relative GTV changes correlated with LRC, distant control (DC), PFS, and OS. Results: Median OS was 28.2 months (CI 19.9-NR) and 2-year LRC was 53.7% (CI 33.1-70.4%). Median GTV-P volumes at each time point were 77.1, 48.3, 42.5, and 29.9 cm3, respectively. After two weeks of treatment, median absolute and relative volume losses were 18.0 cm3 and 30%. After four weeks of treatment, median absolute and relative volume losses were 30.8 cm3 and 50%. UVA showed that greater relative volume loss between fractions 1 and 21 was associated with improved distant control (HR 0.35, CI 0.13-0.94, p=0.038) and OS (HR 0.40, CI 0.16-0.98, p=0.046). Two-year OS rates for patients with relative volume loss above or below the median were 68.2% and 40.2%, respectively. Greater relative volume loss between fractions 11 and 21 was associated with improved PFS (HR 0.39, CI 0.17-0.88, p=0.02), with a trend toward improved OS (HR 0.43, CI 0.17-1.06, p=0.06). On MVA, greater relative volume loss between fractions 11 and 21 correlated with improved PFS (HR 0.39, CI 0.16-0.97, p=0.043) and OS (HR 0.32, CI 0.12-0.86, p=0.023). Conclusion: Significant GTV-P volume loss occurs during definitive chemoradiation for LA-NSCLC. Fifty percent of tumors decreased in volume by >= 30% during the first two weeks of treatment, suggesting a potential role for adaptive radiotherapy. Relative GTV-P volume changes during the first four weeks of treatment correlated with distant control, PFS, and OS. Thus, kV-CBCT can potentially serve as a practical prognostic imaging marker.

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and reproducible position: supine with both arms above their head. For each patient a 4D-CT was acquired in a Philips Brilliance CT. The ITV was delineated according to six breathing phases. In total, 35 fractions were delivered to these patients, who were treated with SBRT without a body frame. Two risk-adapted fractionation schemes were used: 3 fractions of 18 Gy and 5 fractions of 10 Gy. For each fraction, three 4D-CBCT scans were acquired: before treatment to measure and correct the mean tumor position (initial set-up), after correction to validate the correction applied, and after treatment to estimate the intrafraction stability. These scans were volume registered with the localization CT, using a soft-tissue match, in the Elekta XVI software. Corrections were performed by a robotic patient positioning platform (Elekta HexaPOD RT system). Treatment was delivered using 6 MV photons generated from Elekta Synergy Beam Modulator Linac. Patient positioning data from all scans were recorded to determine systematic and random (sigma) set-up errors for initial set-up, after correction and after treatment imaging, in the left-right (X), craniocaudal (Y) and anteroposterior (Z) directions. The ITV to PTV margin (M) was also calculated for after correction and after treatment imaging, using the Van Herk formula: M=2.5 +0.7 sigmaResultsA summary of patient set-up errors and ITV to PTV margins, in the three orthogonal directions, is shown in Table I.

Summary of set-up errors and ITV margins DirectionsCBCT initial set-upCBCT aftercorrectionCBCT aftertreatment(mm)sigma(mm)(mm)sigma(mm)M(mm)(mm)sigma(mm)M(mm)X2.12.20.71.02.51.11.53.8Y5.43.61.31.24.01.51.44.6Z2.62.70.30.81.41.01.23.3Intrafraction stability was 1.1, 0.6 and 1.0 mm (systematic) and 1.2, 0.9 and 1.1 mm (random) for X, Y and Z directions, respectively. Calculated margins do not account for target delineation and organ motion uncertainties and are consistent with our current 7 mm margins in all directions. Conclusion: Frameless SBRT can be safely administrated using 4D-CBCT. This was demonstrated with small intrafraction movements after initial set-up correction using imaging guidance. Our data suggest that lung SBRT should not be delivered without image guidance to correct initial set-up uncertainties owing to the small size of the lesions treated and the large dose delivered each fraction. ITV margins can safely be kept small, allowing patients to benefit of advantages of SBRT.

Database: EMBASE

26. Tumor volume reduction evaluated by CBCT during SBRT treatment for stage I/II NSCLC

Author(s): Gaines D.K.; Hadzitheodorou C.; Osorio B.; Simone C.B.; Kim S.; Nie K.; Aisner J.; Jabbour S.K.; Malhotra J.; Zou W.

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Publication Type(s): Conference Abstract

Available at International Journal of Radiation Oncology Biology Physics - from ScienceDirect

Abstract:Purpose/Objective(s): Stereotactic body radiation therapy (SBRT) is a standard of care for high-risk surgical candidates with stage I/II non-small cell lung cancer (NSCLC). Despite excellent local control rates with SBRT, the overall survival rates for NSCLC are still suboptimal, with 5-year survival rates at approximately at 50-70% and subsets of patients experiencing locoregional and distant recurrences. Several studies across various tumor types have demonstrated the utility of measuring tumor volume reduction (TVR) rates as an effective prognostic marker, but such assessments in SBRT-treated patients are currently lacking. We examined the significance of tumor volume reduction in early stage NSCLC and hypothesized that tumors with a higher TVR rate will be less likely to experience tumor recurrence. Purpose/Objective(s): Under an IRB approved protocol, we retrospectively reviewed 73 patients across 2 institutions that were screened for recurrence of node-negative early stage NSCLC after SBRT. We specifically included patients who experienced local (n=5), regional (n=11), and distant (n=11) recurrences to assess whether TVR would be a useful
predictive factor. Gross tumor volume (GTV) was calculated from cone beam computed tomography (CBCT) images taken before each radiation fraction, and these images were also used to calculate TVR which was defined by the percentage change in GTV between the fraction start date and last fraction. Using median TVR, we stratified study participants into 2 main groups: TVR >= median reduction and TVR < median reduction. Log rank test was used to statistically analyze survival and recurrence outcomes. Results: Our cohort included 37 men and 35 women with a median age at treatment of 75 years (range 48-90). These patients received a median total radiation dose of 5000cGy (range 4250-6000cGy) over a median of 5 fractions (range 3-5). The median baseline GTV, median post-SBRT GTV and median TVR were 10.28cm³ (range 0.42-93.31 cm³), 8.44cm³ (range 0.25-87.49 cm³), and 10.08%, respectively. Median overall survival was 30.7 months (95% C.I. = [22.79, -]) for TVR >= median reduction and 28.62 months (95% C.I. = [12.1, -]) for TVR< median reduction (p=0.473). There were no observed relationships between TVR and local (p=0.406), regional (p=0.423), or distant (p=0.374) recurrences. Conclusion: Our data suggests that TVR is not prognostic for early stage NSCLC. Additional assessment of a larger cohort of patients with and without recurrence is currently being conducted to determine whether TVR can provide additional insight into early stage NSCLC recurrence and overall survival.

Database: EMBASE

27. Clinical outcomes for frameless image-guided stereotactic radiation therapy to intact brain metastases in five daily hypofractionated treatments

Author(s): Myrehaug S.; Soliman H.; Tseng C.L.; Tsao M.; Sahgal A.; Ruschin M.E.

Source: International Journal of Radiation Oncology Biology Physics; Oct 2017; vol. 99 (no. 2)

Publication Date: Oct 2017

Publication Type(s): Conference Abstract

Available at International Journal of Radiation Oncology*Biology*Physics - from ScienceDirect

Abstract:

Purpose/Objective(s): Image-guided multi-lead collimator (MLC) linac-based hypofractionated stereotactic radiation (FSRT) is increasingly practiced for brain metastases. We report our outcomes for 5-fraction FSRT including the rate of radiation necrosis.

Purpose/Objective(s): 113 patients with 184 brain metastases who were treated with FSRT from Oct 2009-Dec 2014 were retrospectively reviewed. Overall Survival (OS) and progression free survival (PFS) rates were calculated using the Kaplan-Meier method. Local control rates were determined with Fine and Gray's competing risk method with death as the competing risk. Predictive factors were identified using Cox regression multivariable analysis. All patients were treated in a thermoplastic mask using a cone-beam CT image-guided linac equipped with a MLC and six-degrees-of-freedom treatment couch. All patients were treated with a 5 daily fraction dose scheme to the gross tumor volume (GTV) with a 2 mm planning target volume (PTV). 30 Gy in 5 fractions was the most common prescription. Results: The median follow-up was 11 months. Non-small cell lung cancer the most frequently treated histology (46%) followed by breast cancer (21%) and melanoma (9%). FSRT was given for a single brain metastasis in 67 (59%) patients and for multiple metastases in 46 patients (41%). 77 patients (68%) were treated as upfront and 36 (32%) as salvage following whole brain radiation. 50 patients (44%) had treated lesions >2 cm in maximum diameter. 43 targets (23%) received 25-27.5Gy, 111 (60%) received 30 Gy, and 30 (16%) received >30 Gy in 5 fractions. The PFS rates at 6 months, 12 months and 24 months were 65%, 38%, and 15%, respectively (median, 9.0 months). The OS rates at 6 months, 12 months and 24 months were 69% 47% and 20%, respectively (median OS, 11.8 months). The local failure rates at 6 months, 12 months and 24 months were 8.2%, 22% and 35%, respectively (median, 11.43 months). With regards to other patterns of failure, cumulative incidence rates of leptomeningeal disease at 6 months, 12 months...
and 24 months were 9.8%, 14% and 17% respectively (median, 4.4 months). 28 targets in 25 patients (15%) developed radiation necrosis, of which 17 were symptomatic (9%). Post-treatment necrosis was a positive prognostic factor (HR 2.1, \( p=0.003 \)) for OS. Upfront therapy as opposed to salvage (HR 0.54, \( p=0.02 \)) and those treated with doses > 30Gy (HR 0.55, \( p=0.03 \)) were predictive for local control. Conclusion: Frameless image-guided MLC-based linac FSRT for intact brain metastasis results in long-term local control with an acceptable rate of RN.

Database: EMBASE

28. Improvement of dose calculation with scattered photon-corrected KV cone-beam CT image using the kernel deconvolution method

Author(s): Usui K.; Sasai K.; Kubota S.; Ogawa K.

Source: International Journal of Radiation Oncology Biology Physics; Oct 2017; vol. 99 (no. 2)

Publication Date: Oct 2017

Publication Type(s): Conference Abstract

Available at International Journal of Radiation Oncology*Biology*Physics - from ScienceDirect

Abstract: Purpose/Objective(s): Intensity modulated radiation therapy (IMRT) and stereotactic body radiation therapy (SBRT) has to be accomplished with a dose distribution in terms of changes in the tumor size and position for minimizing adverse effects on neighboring organs. If cone-beam computed tomography (CBCT) would facilitate dose calculation attached to the IMRT or SBRT apparatus, we could use the CBCT-based adaptive radiation therapy (ART). However, a CBCT image cannot achieve quantitative electron density values owing to scattered photons; thus, we cannot use it directly for dose calculation. In this study, we calculated the distribution of scattered photons in CBCT images using the Monte Carlo (MC) method and corrected the scattered photon effect with scatter kernels in the process of image reconstruction with the maximum likelihood expectation maximization (MLEM) method. Moreover, we investigated the accuracy of dose calculation by this segmented region method in comparison with typical methods by replacing CBCT values with ideal density values. Purpose/Objective(s): We calculated the distribution of scattered photons with slab phantoms using the MC method and acquired scattered kernels of three materials (bone, water, and lungs) having different thicknesses until 20 cm every 0.1 cm. These kernels were used in the MLEM method for correcting scattered photons in lung and pelvis CBCT images. Next, we segmented CBCT and multislice CT (MSCT) images into three regions (lungs, bones, and soft tissues) and compared segmentation accuracy between MSCT and scatter-corrected CBCT images. Moreover, we evaluated the effectiveness of dose calculation by CBCT images. In the CBCT to density conversion method, we converted the CBCT value using individual three tables in each organ, and in the density overriding method, we observed calculated doses on accurate organ-segmented images using gamma and dose-volume histogram (DVH) analyses. Results: Segmentation results showed that the threshold value of bone and soft tissue separation was similar to the ideal threshold value used in MSCT images; the segmentation error ratio improved (w/o: 63.0%, w/: 4.7%). Similarly, segmentation error ratios for lungs and soft tissues improved by 8.6% compared with those observed on the original CBCT image. In the CBCT to density conversion method, differences in target doses of MSCT and CBCT with scatter corrections were small in the DVH analysis. In the density overriding method, gamma analysis results showed that the calculated dose distributions with scatter-corrected images were similar to those seen in MSCT; the pass rate was significantly higher with an accurate segmentation effect (w/o: 70.1%, w/: 95.9%). Conclusion: We evaluated the effectiveness of scattered photon-corrected CBCT image using the kernel deconvolution method for organ segmentation and the effect of this contribution on dose calculation. Improvement of the
segmentation accuracy with scattered photon correction can be observed using CBCT dose calculation for ART.

**Database:** EMBASE

### 29. Feasibility of using single photon counting X-ray for lung tumor position estimation based on 4D-CT.

**Author(s):** Aschenbrenner, Katharina P; Guthier, Christian V; Lyatskaya, Yulia; Boda-Heggemann, Judit; Wenz, Frederik; Hesser, Jürgen W

**Source:** Zeitschrift fur medizinische Physik; Sep 2017; vol. 27 (no. 3); p. 243-254

**Publication Date:** Sep 2017

**Publication Type(s):** Journal Article

**PubMedID:** 28595774

**Abstract:** PURPOSE In stereotactic body radiation therapy of lung tumors, reliable position estimation of the tumor is necessary in order to minimize normal tissue complication rate. While kV X-ray imaging is frequently used, continuous application during radiotherapy sessions is often not possible due to concerns about the additional dose. Thus, ultra low-dose (ULD) kV X-ray imaging based on a single photon counting detector is suggested. This paper addresses the lower limit of photons to locate the tumor reliably with an accuracy in the range of state-of-the-art methods, i.e. a few millimeters.

**METHOD** 18 patient cases with four dimensional CT (4D-CT), which serves as a-priori information, are included in the study. ULD cone beam projections are simulated from the 4D-CTs including Poisson noise. The projections from the breathing phases which correspond to different tumor positions are compared to the ULD projection by means of Poisson log-likelihood (PML) and correlation coefficient (CC), and template matching under these metrics.

**RESULT** The results indicate that in full thorax imaging five photons per pixel suffice for a standard deviation in tumor positions of less than half a breathing phase. Around 50 photons per pixel are needed to achieve this accuracy with the field of view restricted to the tumor region. Compared to CC, PML tends to perform better for low photon counts and shifts in patient setup. Template matching only improves the position estimation in high photon counts. The quality of the reconstruction is independent of the projection angle.

**CONCLUSION** The accuracy of the proposed ULD single photon counting system is in the range of a few millimeters and therefore comparable to state-of-the-art tumor tracking methods. At the same time, a reduction in photons per pixel by three to four orders of magnitude relative to commercial systems with flatpanel detectors can be achieved. This enables continuous kV image-based position estimation during all fractions since the additional dose to the patient is negligible.

**Database:** Medline

### 30. Inhibition of ataxia telangiectasia related-3 (ATR) improves therapeutic index in preclinical models of non-small cell lung cancer (NSCLC) radiotherapy.

**Author(s):** Dunne, Victoria; Ghita, Mihaela; Small, Donna M; Coffey, Caroline B M; Weldon, Sinead; Taggart, Clifford C; Osman, Sarah O; McGarry, Conor K; Prise, Kevin M; Hanna, Gerard G; Butterworth, Karl T

**Source:** Radiotherapy and oncology : journal of the European Society for Therapeutic Radiology and Oncology; Sep 2017; vol. 124 (no. 3); p. 475-481

**Publication Date:** Sep 2017

**Publication Type(s):** Research Support, Non-u.s. Gov't Journal Article
PubMedID: 28697853

Abstract: BACKGROUND AND PURPOSE To evaluate the impact of ATR inhibition using AZD6738 in combination with radiotherapy on the response of non-small cell lung cancer (NSCLC) tumour models and a murine model of radiation induced fibrosis. MATERIALS AND METHODS AZD6738 was evaluated as a monotherapy and in combination with radiation in vitro and in vivo using A549 and H460 NSCLC models. Radiation induced pulmonary fibrosis was evaluated by cone beam computed tomography (CBCT) and histological staining. RESULTS AZD6738 specifically inhibits ATR kinase and enhanced radiobiological response in NSCLC models but not in human bronchial epithelial cells (HBECs) in vitro. Significant tumour growth delay was observed in cell line derived xenografts (CDXs) of H460 cells (p<0.5) and histological scoring of radiation induced fibrosis (p>0.5). CONCLUSION Inhibition of ATR with AZD6738 in combination with radiotherapy increases tumour growth delay without observable augmentation of late radiation induced toxicity further underpinning translation towards clinical evaluation in NSCLC.

Database: Medline

31. Feasibility of CBCT-based dose with a patient-specific stepwise HU-to-density curve to determine time of replanning.

Author(s): Chen, Shifeng; Le, Quynh; Mutaf, Yildirim; Lu, Wei; Nichols, Elizabeth M; Yi, Byong Yong; Leven, Tish; Prado, Karl L; D'Souza, Warren D

Source: Journal of applied clinical medical physics; Sep 2017; vol. 18 (no. 5); p. 64-69

Publication Date: Sep 2017

Publication Type(s): Journal Article

PubMedID: 28703475

Abstract: PURPOSE (a) To investigate the accuracy of cone-beam computed tomography (CBCT)-derived dose distributions relative to fanbeam-based simulation CT-derived dose distributions; and (b) to study the feasibility of CBCT dosimetry for guiding the appropriateness of replanning. METHODS AND MATERIALS Image data corresponding to 40 patients (10 head and neck [HN], 10 lung, 10 pancreas, 10 pelvis) who underwent radiation therapy were randomly selected. Each patient had both intensity-modulated radiation therapy and volumetric-modulated arc therapy plans; these 80 plans were subsequently recomputed on the CBCT images using a patient-specific stepwise curve (Hounsfield units-to-density). Planning target volumes (PTVs; D98%, D95%, D2%), mean dose, and V95% were compared between simulation-CT-derived treatment plans and CBCT-based plans. Gamma analyses were performed using criterion of 3%/3 mm for three dose zones (>90%, 70%~90%, and 30%~70% of maximum dose). CBCT-derived doses were then used to evaluate the appropriateness of replanning decisions in 12 additional HN patients whose plans were previously revised during radiation therapy because of anatomic changes; replanning in these cases was guided by the conventional observed source-to-skin-distance change-derived approach. RESULTS For all disease sites, the difference in PTV mean dose was 0.1% ± 1.1%, D2% was 0.7% ± 0.1%, D95% was 0.2% ± 1.1%, D98% was 0.2% ± 1.0%, and V95% was 0.3% ± 0.8%; For 3D dose comparison, 99.0% ± 1.9%, 97.6% ± 4.4%, and 95.3% ± 6.0% of points passed the 3%/3 mm criterion of gamma analysis in high-, medium-, and low-dose zones, respectively. The CBCT images achieved comparable dose distributions. In the 12 previously replanned 12 HN patients, CBCT-based dose predicted well changes in PTV D2% (Pearson linear correlation coefficient = 0.93; P < 0.001). If 3% of change is used as the replanning criteria, 7/12 patients could avoid replanning. CONCLUSIONS CBCT-based dose calculations produced accuracy comparable to that of simulation CT. CBCT-based dosimetry can guide the decision to replan during the course of treatment. Database: Medline
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