

METACHRONOUS STAGE I NON-SMALL CELL LUNG CARCINOMA



**Georgetown University Hospital
CyberKnife Team:**

Radiation Oncologist: Brian T. Collins, MD
Medical Physicist: Sonja Dieterich, PhD
Radiation Therapist: Gerard Elie, RTT

CyberKnife Center:
Georgetown University Hospital
Washington, DC

METACHRONOUS STAGE I NSCLC

DEMOGRAPHICS:

Sex: F
Age: 64
Histology: Pulmonary adenocarcinoma, bronchoalveolar type.
Treat Date(s): 10/25/04 – 11/02/04

CLINICAL HISTORY:

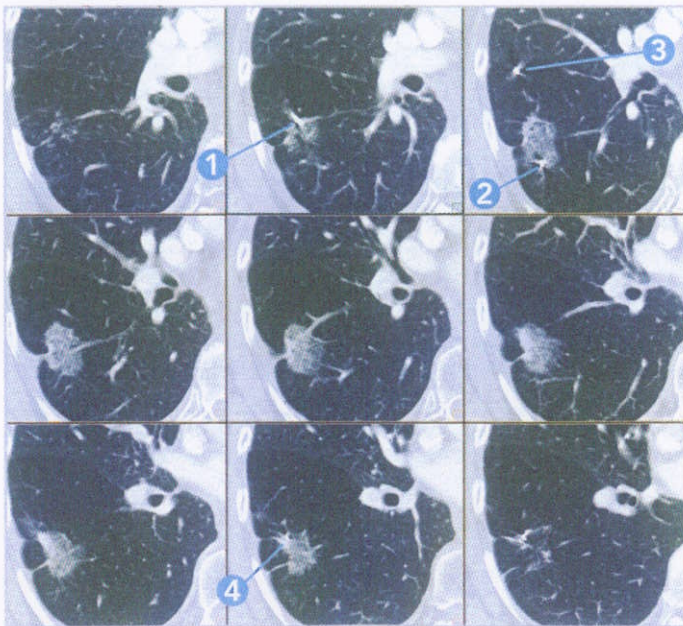
Referred by: Pulmonologist
Past Medical History: Stage III non-small cell lung cancer (NSCLC) of the left upper lobe diagnosed in 1999, Chronic Obstructive Pulmonary Disease (COPD), smoker

Case History:

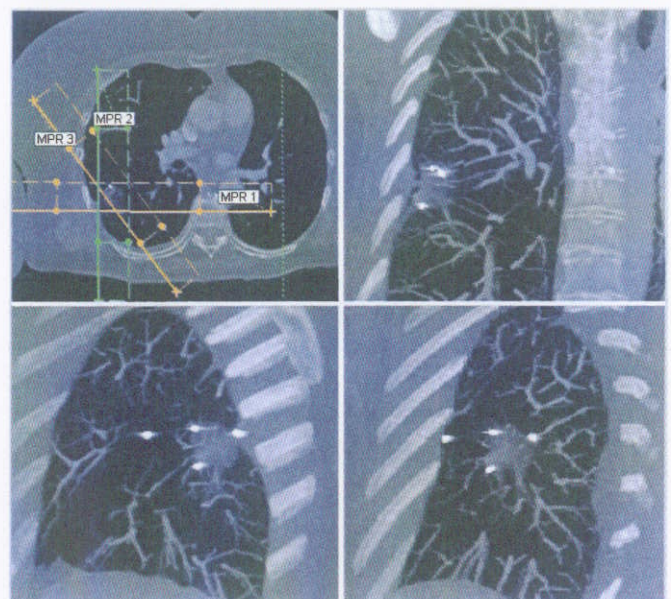
A 64-year-old female ex-heavy smoker with severe COPD and a history of Stage III NSCLC in the left upper lobe, treated with conventional radiation and chemotherapy in 1999, presented with a new 3-cm right lower lobe (RLL) ground glass opacity. CT-guided needle biopsy completed in July 2004 confirmed well-differentiated pulmonary adenocarcinoma of the bronchoalveolar type. Given this patient's complete response to treatment for her poorly differentiated adenocarcinoma five years prior, this new RLL adenocarcinoma was classified as a metachronous Stage I lung cancer. The patient's COPD had progressed since her prior radical conventional chemoradiation treatment in 1999, with a current forced expiratory volume in one second (FEV1) of 1.13 liters.

CyberKnife Treatment Rationale:

Stage I NSCLC is typically treated by primary surgical resection (lobectomy or more limited resections, such as wedge resections).^{1,2} Conventional radiation has been reserved for patients who refuse surgery or are deemed medically inoperable because of associated co-morbidities.³ This patient's severe COPD made her a poor surgical candidate.² Her significant pulmonary disease and prior conventional radiation increased the risks of treatment by conventional radiation.³ Furthermore, pretreatment fluoroscopic exam revealed substantial tumor excursion with respiration (longitudinal motion with an amplitude of 3 cm). Accounting for this degree of tumor motion would require large margins of normal tissue to be irradiated, further increasing the risks of radiation pneumonitis.³ To minimize morbidity for this high-risk patient, a viable treatment would have to target the tumor precisely and maximally spare normal lung tissue. The CyberKnife[®] equipped with the Synchrony[®] Respiratory Tracking System allows the accurate delivery of high-dose radiation to moving lung tumors, thereby minimizing harmful effects to normal surrounding tissue.⁴



Pretreatment diagnostic 3.0-mm CT sections showing the tumor and 4 implanted fiducials.



Coronal, sagittal and oblique multiplanar reformations taken from 1.0-mm planning CT showing placement of fiducials near the tumor.

METACHRONOUS STAGE I NSCLC

TREATMENT DETAILS:

Tumor Volume: 11.84 cm³
Imaging Technique(s): CT
Rx Dose & Isodose: 54 Gy to 80%
Conformality Index: 1.97
Tumor Coverage: 99%

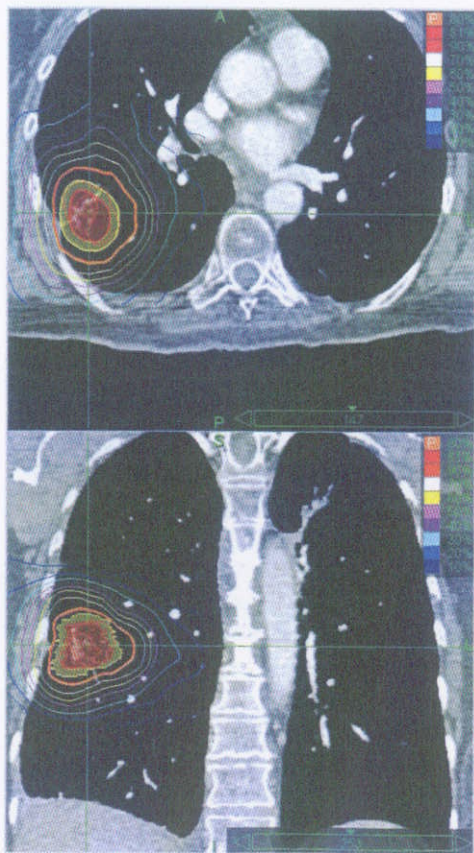
Fractions / Treatment Time: 3 / 97 min average per fraction
Path Template: 3 path 900_1000 mm
Tracking Method: Synchrony with 4 Fiducials
Collimator(s): 30 mm
Number of Beams: 172

Planning Process and Goals:

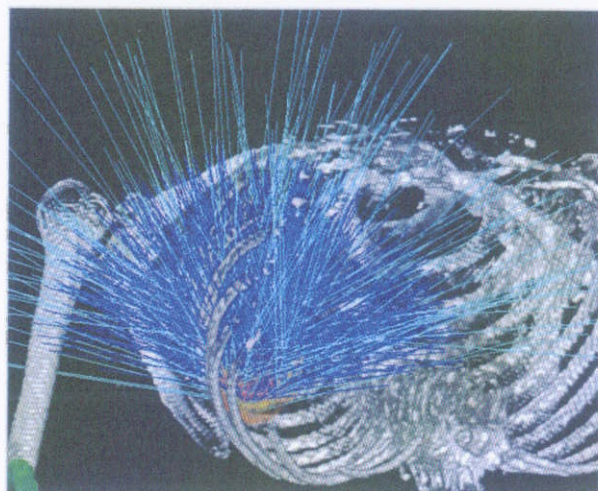
The patient was prepared for treatment planning by placing 4 fiducials near the RLL tumor percutaneously under CT guidance. A planning CT was obtained 7 days later. Fiducials were identified and the lesion was outlined on the scan, resulting in a target volume of 11.84 cm³. A treatment plan was developed using the MultiPlan™ treatment planning system. The final plan was created to deliver 54 Gy in 3 fractions to the 80% isodose line, with 5-mm tumor margins, using a 30-mm collimator. The V₂₀ (volume of lung receiving greater than 20 Gy) was less than 10%.

Treatment Delivery:

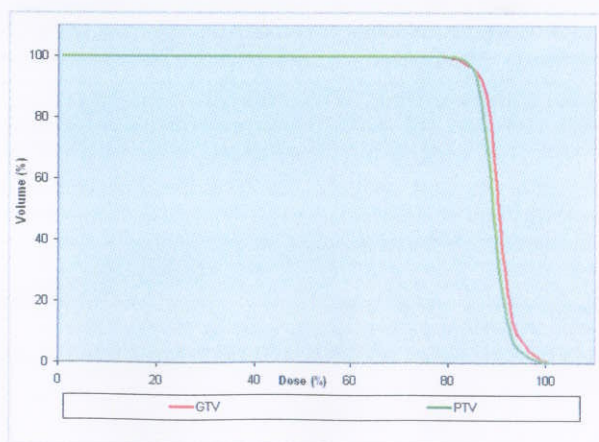
The patient underwent CyberKnife treatment using 172 beams. The prescribed dose covered 99% of the planning target volume (PTV) with a homogeneity index of 1.25 and a conformality index of 1.97. The amount of surrounding normal lung parenchyma was maximally spared and the patient tolerated the procedure well.



Axial and coronal planning images showing gross tumor volume (GTV) in red and planning tumor volume in yellow. The 80% isodose line (representing a prescription dose of 54 Gy) is shown in orange.



3D rendering of bony anatomy and CyberKnife beam positions to the RLL tumor.



Dose Volume Histograms (DVH) for GTV (red) and PTV (green).

METACHRONOUS STAGE I NSCLC

Outcome and Follow-Up:

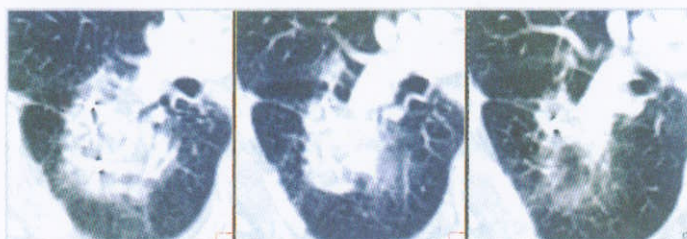
- Three months after CyberKnife treatment, CT scan revealed a decrease in size of the RLL lesion measuring 2.0 x 2.5 cm. The patient experienced a minor exacerbation of her COPD with complaints of dyspnea. The patient was treated conservatively and her symptoms completely resolved by 4 months post-treatment. Patient's pulmonary function tests (PFTs) remained at pretreatment levels during this period.
- Six months after CyberKnife treatment, the RLL mass was not visualized on the patient's CT scan. Signs of pulmonary fibrosis and scarring were evident on CT images. No new clinical respiratory symptoms were noted.
- These findings remained stable with no new disease at 20 months post-treatment. A ball-like region of radiation fibrosis was noted in the region of the CyberKnife treatment field. PFT values were maintained at pretreatment levels and the patient remained asymptomatic. Two-year follow-up PET-CT scan demonstrated mild diffuse hypermetabolism in the RLL most likely related to post-radiation changes and no evidence of recurrent tumor.



3 months post CyberKnife



6 months post CyberKnife



20 months post CyberKnife

Conclusion and CyberKnife Advantages:

- This patient had an excellent initial outcome with CyberKnife using Synchrony motion tracking in the treatment of her RLL lung tumor. Normal lung tissue was maximally spared and pretreatment PFTs and functional status were maintained.
- CyberKnife can deliver complex treatment plans to lesions within the lung while minimizing irradiation to the surrounding healthy tissue, thereby decreasing the risk of complications, such as radiation pneumonitis.
- CyberKnife is a potential excellent treatment modality for patients with lung tumors who refuse surgery and for those patients who are deemed medically inoperable because of co-morbidities and poor functional status.

CYBERKNIFE AT GEORGETOWN UNIVERSITY HOSPITAL (www.georgetownuniversityhospital.org)

Georgetown University Hospital's (GUH) CyberKnife® Robotic Radiosurgery System, installed in 2002, was the first system on the East Coast. The Synchrony® Respiratory Tracking System was added in 2004 and Xsight™ Spine Tracking in 2006. The CyberKnife allows GUH physicians to provide a targeted, minimally invasive alternative to open surgery and a treatment option for certain tumors that are otherwise untreatable. GUH physicians and the Radiation Oncology Department have created a multi-disciplinary approach to provide their patients with the most comprehensive diagnosis and treatment process possible. Over 400 patients were treated in 2006, with a clinical workload of 45% intracranial, 20% spine and 35% extracranial non-CNS. GUH physicians recently treated their 1500th patient with the CyberKnife.

References:

1. Jones DR, Detterbeck FC. Surgery for stage I nonsmall cell lung cancer. In: Detterbeck FC, Rivera MP, Socinski MA, Rosenman JG, eds. **Diagnosis and treatment of lung cancer: An evidence-based guide for the practicing clinician.** pp 177-190. Philadelphia: W.B. Saunders Company, 2001.
2. Bernard A, Ferrand L, Hagry O, Benoit L, Cheynel N, Favre J-P. Identification of prognostic factors determining risk groups for lung resection. **Ann Thoracic Surg** 70(4):1161-1167, 2000.
3. Harpole DH, Jr., DeCamp MM, Jr., Daley J, Hur K, Oprian CA, Henderson WG, Khuri SF. Prognostic models of thirty-day mortality and morbidity after major pulmonary resection. **J Thoracic Cardio Surg** 117(5):969-979, 1999.
4. Whyte RI, Crownover R, Murphy MJ, Martin DP, Rice TW, DeCamp MM Jr, Rodebaugh R, Weinhaus MS, Le QT. Stereotactic radiosurgery for lung tumors: Preliminary report of phase I trial. **Ann Thoracic Surg** 75(4):1097-1101, 2003.



© 2006 Accuray Incorporated. All rights reserved. Accuray, the Accuray logo, CyberKnife, Synchrony, Xsight and CyRIS are among trademarks or registered trademarks of Accuray, Inc. This case study was produced by its authors with editorial and graphics assistance from the clinical development group at Accuray Incorporated.

