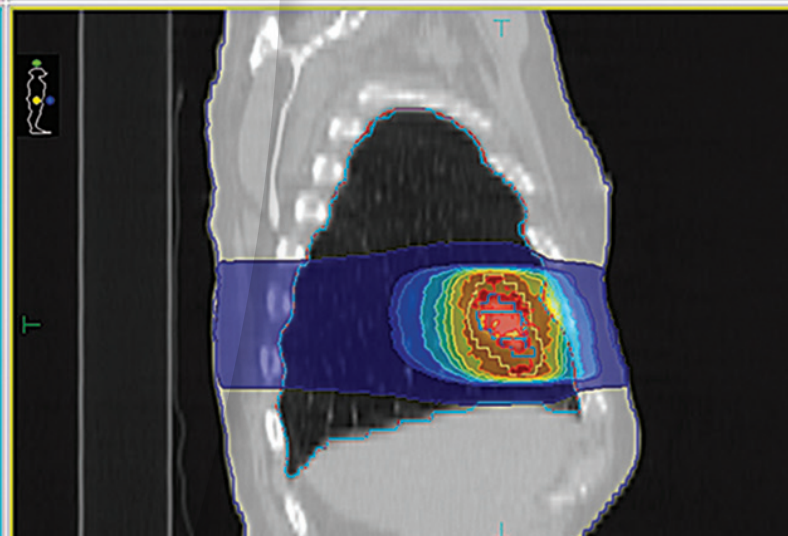
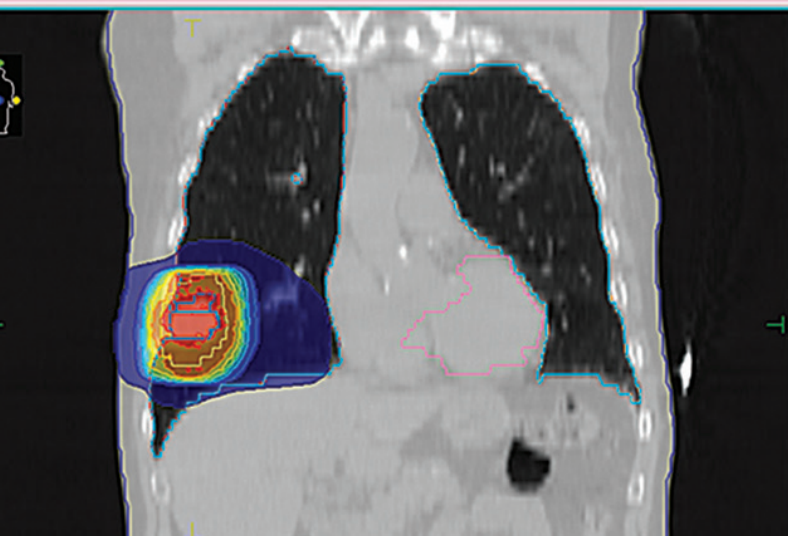
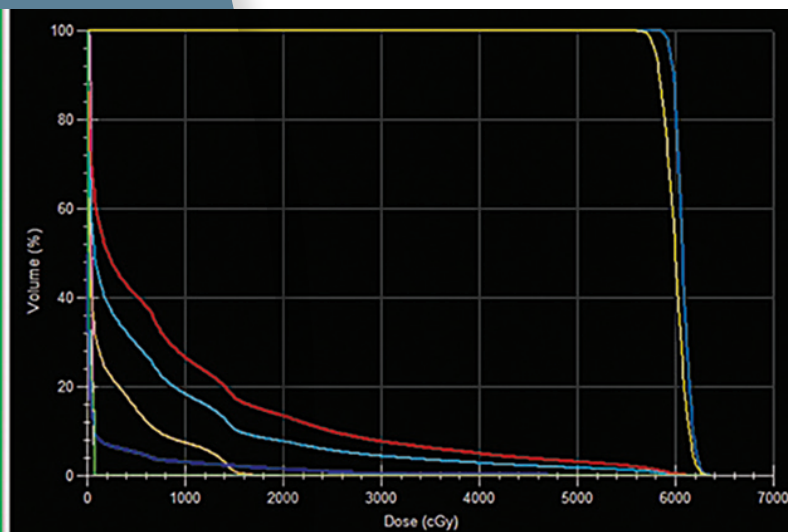
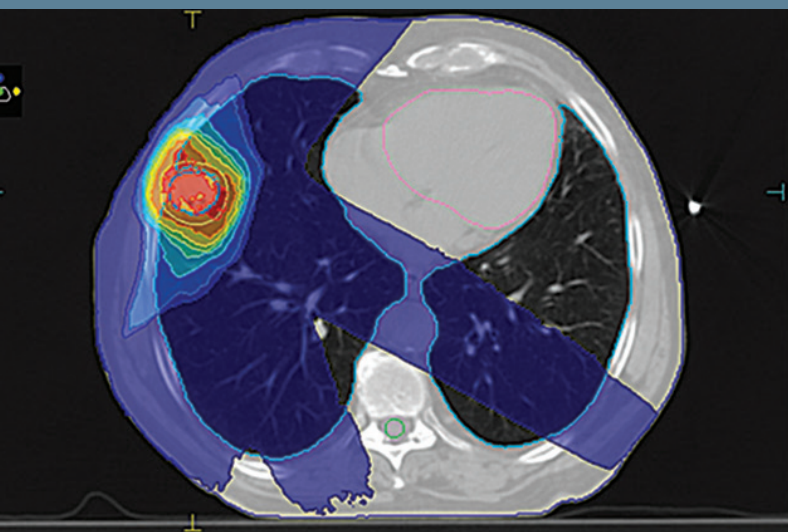


# SBRT for NSCLC using Versa HD™

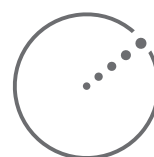
with flattening filter-free beams  
(High Dose Rate mode) and Active  
Breathing Coordinator™

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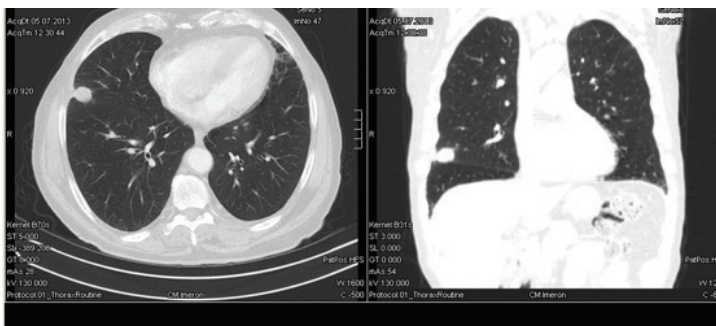
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## Summary

Patient demographics:	Treatment:
91 year old male with a history of high blood pressure and deep vein thrombosis, on Coumadin therapy	12 Gy x 5 fractions = 60 Gy (median PTV dose)
2.5 cm lesion in lower lobe of right lung	Versa HD™: <ul style="list-style-type: none"> <li>• 10 MV photon linear accelerator</li> <li>• Active Breathing Coordinator™</li> <li>• Agility™ dynamic MLC</li> <li>• Flattening filter-free mode</li> </ul>
Diagnosis: Stage IA, T1b N0 M0 squamous cell carcinoma	Total time for acquisition of cone beam CT and delivery of 12 Gy was 15 minutes



Diagnostic CT revealed a 2.5 cm lesion located in the lower lobe of the right lung

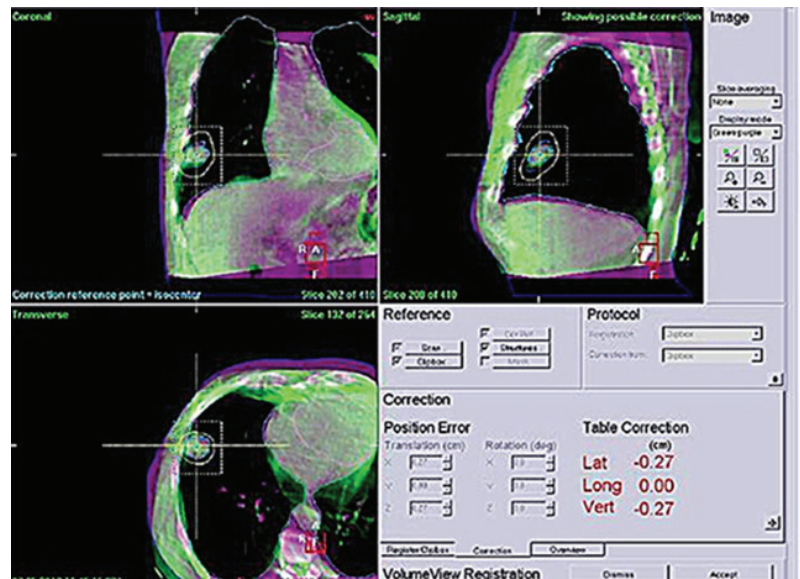
## Patient History and Diagnosis:

A 91 year-old male initially presented with hemoptysis in April 2013. The patient had a history of high blood pressure, deep vein thrombosis and was on Coumadin therapy. A diagnostic computed tomography (CT) scan revealed a 2.5 cm lesion located in the right lower lobe of the lung. The patient underwent a trans-thoracic biopsy of the right lower lobe lesion which confirmed squamous cell carcinoma of the lung. The patient was clinically staged T1b, N0, M0.

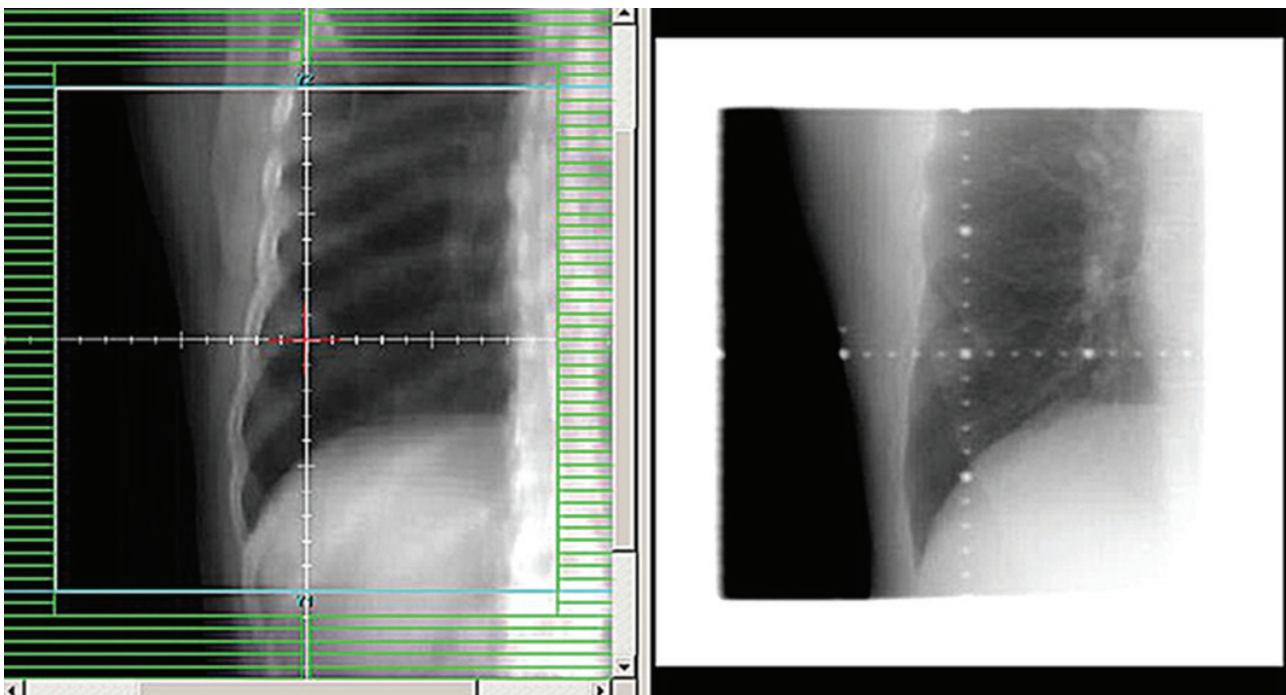
The standard treatment for early-stage lung cancer in medically operable patients is surgery. For those patients that are medically or surgically inoperable, stereotactic radiotherapy (SBRT) is an acceptable treatment option. SBRT has been shown to achieve high local control and good overall survival rates for early-stage NSCLC patients who are not surgical candidates or refuse surgery.<sup>1-3</sup> Because of this patient's co-morbidities and advanced age, the patient refused surgical lobectomy and elected for non-invasive SBRT.

#### Treatment Planning using Active Breathing Coordinator™:

Accurate target localization and reliable prediction of respiratory motion is a challenge when treating tumors that move with respiration. The Active Breathing Coordinator (Elekta AB, Stockholm, Sweden) minimizes respiratory motion during SBRT treatment and provides a non-invasive, internal immobilization of anatomies affected by respiratory motion through a comfortable and reproducible breath-hold technique. Centers are using the Active Breathing Coordinator to minimize tumor motion during respiration and to reduce treatment margins.<sup>4-5</sup>



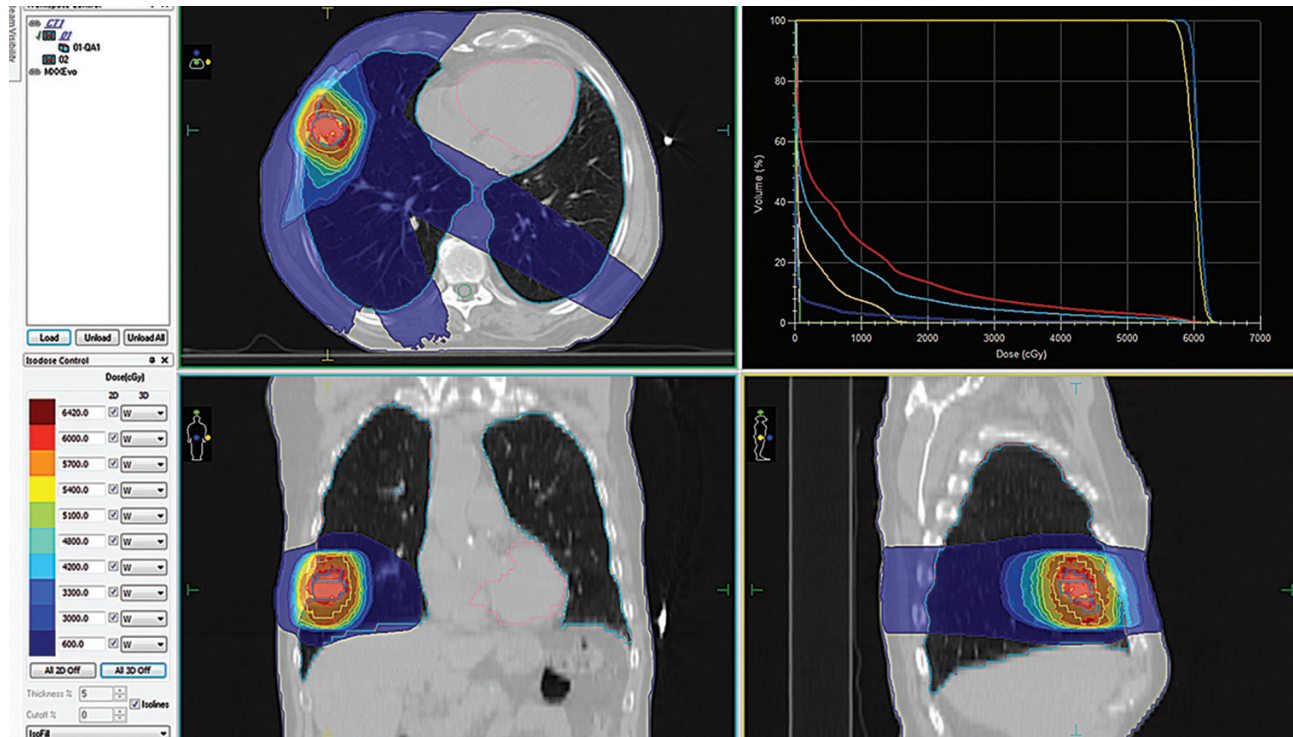
Superposition of breath-hold treatment planning CT and cone beam CT acquired during repetitive breath-hold



Digitally reconstructed radiograph and corresponding MV-EPID acquired under breath-hold



For treatment planning and treatment delivery, this patient was immobilized on a breast board (Wing-board [I-TV, Austria]). The patient underwent a training session for inspiratory breath hold at approximately 70% of vital capacity using the Active Breathing Coordinator. The patient breath-hold time was set to 15 seconds and the threshold was set at 1.5 liters. The treatment planning CT was acquired with a spiral-CT (Brilliance Big Bore Oncology, Philips, Hamburg, Germany). The planning target volume (PTV) was calculated from the clinical target volume (CTV) by adding a 5 mm margin radially and an 8 mm margin in the craniocaudal direction to compensate for potential residual intrafraction error based on the Active Breathing Coordinator based positioning. The final CTV volume was 10.4 cm<sup>3</sup> and the respective PTV volume was 38 cm<sup>3</sup>. An intensity-modulated radiotherapy plan for the Versa HD™ was generated with the treatment planning software Monaco® version 3.3 (Elekta AB, Stockholm, Sweden). The final plan included 7 beams to deliver a prescribed dose of 60 Gy in 5 fractions of 12 Gy per fraction.



The treatment plan consisted of 7 beams with a prescribed dose of 60 Gy delivered in 5 fractions of 12 Gy per fraction.

Critical structure	Dose Constraints
Ipsilateral (right) lung	V20Gy: 13%
Esophagus	Dmax: 6 Gy
Heart	Dmax: 0.8 Gy Dmean: 0.4 Gy
Brachial plexus	< 0.1 Gy
Spinal cord	Dmax: 0.8 Gy

### **Treatment Delivery using Active Breathing Coordinator™ and Flattening Filter-Free Beams:**

On the day of treatment, the patient was set-up using Active Breathing Coordinator and repeat breath-hold cone-beam CT imaging. The set-up time was completed in 8 minutes. Individual plan verification for quality assurance was completed before application of the first treatment fraction using a 2D array attached to the gantry (MatriXX, IBA Dosimetry). Daily image-guidance was performed with repeat-breath-hold cone-beam CT (XVI\*, Elekta AB, Stockholm, Sweden). Planning CT images were matched online with the daily cone-beam CT images using manual fusion with respect to soft tissue anatomy. Beam delivery was started manually immediately when the patient had reached the pre-defined threshold with Active Breathing Coordinator. Beam delivery was not started or was immediately stopped, respectively, if any irregularity was detected in the inhalation pattern or the patient behavior during breath-hold.

The treatment was performed on the 10 MV photon Versa HD™ linear accelerator (Elekta AB, Stockholm, Sweden) equipped with the Agility™ dynamic MLC and operated in flattening filter free mode. The Agility dynamic MLC is composed of 160 leaves with a 5 mm leaf width at the isocenter and with maximum leaf speed of 6.5 cm per second.

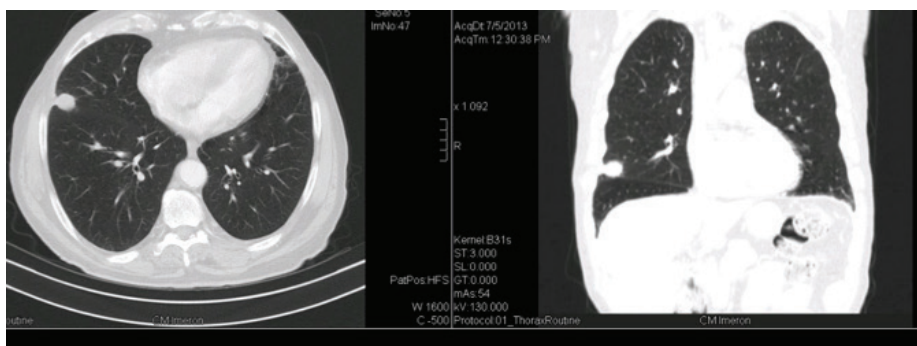
Flattening filter-free beams operate at higher dose rates and have been shown to shorten beam on time. During one breath-hold session of 15 seconds, a complete delivery of 238 MU/1.7 Gy with the dynamic MLC was possible. To deliver a total dose of 12 Gy, 8 breath-hold sessions of 15 seconds each were performed with a total beam on time of less than two minutes.

The treatment time from the start of the first beam until the completion of one fraction was approximately six minutes. Thus, the total on-couch time including the breath-hold weighted cone-beam CT and the delivery of one fraction of 12 Gy was 15 minutes. The patient was treated every other day for 5 days over a 10 day period. The total number of monitor units delivered was 2300.

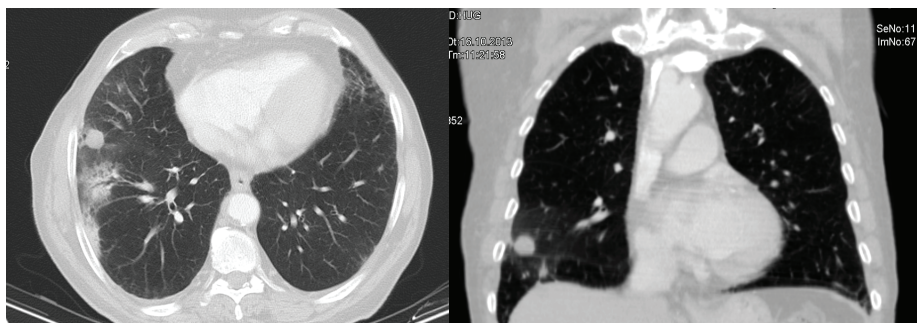
### **Outcome and Follow-Up:**

The patient completed his course of SBRT successfully with no interruptions or side effects. At six-weeks after treatment, the patient reported no hemoptysis, no coughing, or other acute side effects.

At six months after treatment, the patient remained asymptomatic with a Karnofsky performance status of 90-100%. The six-month CT scan showed a 1.5 cm x 1.6 cm treated lesion, thus a moderate reduction in tumor volume. There was radiographic indication of localized pneumonitis on the right side, although the patient had no clinical symptoms.



CT scan 6 weeks post SBRT treatment



CT scan shows lesion with a moderate reduction in diameter at 6 months after SBRT treatment

### Discussion and Conclusion:

The patient had an excellent initial outcome with resolution of hemoptysis and no reported treatment-related toxicities following SBRT treatment using the Versa HD™ with flattening filter-free beams (High Dose Rate mode) and Active Breathing Coordinator.

With co-morbidities and advanced age, the Active Breathing Coordinator breath-hold technique was feasible for managing respiratory motion as part of a lung SBRT protocol.

Relying on the combination of flattening filter-free beams with Active Breathing Coordinator, a safe high-dose per fraction was enabled within an allotted 15 minute treatment time slot. Further, escalated dose delivery times were abbreviated with the potential to improve patient acceptance and comfort.

### References

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