Stereotactic body radiotherapy for early stage non-small cell lung cancer using deep inspiration breath hold and Calypso anchored Beacon transponders

Memorial Sloan Kettering Cancer Center

Introduction

Lung cancer is the most common form of cancer in men, and the third most common cancer in women worldwide. Most patients with lung cancer—more than 80%—are diagnosed with non-small cell lung cancer (NSCLC). Advances in imaging and new treatment delivery approaches that reduce target margins have improved the diagnostic, staging and treatment options available for these patients.

According to National Comprehensive Cancer Network (NCCN) guidelines, the standard of care for patients with early stage NSCLC is surgical resection and definitive radiotherapy including stereotactic body radiotherapy (SBRT). In patients with medically inoperable early stage NSCLC, treatment with SBRT is considered standard of care.

Case report

A 60-year-old male with Stage I NSCLC underwent surgical resection and was referred for SBRT treatment after developing a medically inoperable tumor. Initially, the patient had a tumor in the right middle lobe, and another in the left upper lobe, both of which were surgically resected. Following these two surgeries, the patient developed another right hilar tumor (Figure 1) close to the proximal bronchial tree (Figure 2) as shown by lung CT scan. The patient was considered medically inoperable due to his prior surgeries and limited lung function, based on pulmonary function tests.

"In accordance with treatment guidelines for Stage I medically inoperable NSCLC, lung SBRT was chosen as the best treatment option for this patient," said Andreas Rimner, MD, a radiation oncologist specializing in thoracic cancers at Memorial Sloan Kettering Cancer Center (MSK).

Treatment protocol

Based on the individual characteristics of this patient and the course of treatment selected, the patient was enrolled in a deep inspiration breath hold (DIBH) study underway at MSK. The primary purpose of the
study was to evaluate the use of the Calypso® system with DIBH as a way to effectively locate and track tumor motion during radiation treatment. To provide a reliable surrogate for the tumor position, Calypso Anchored Beacon® transponders were implanted in the lung. The Calypso system was used to detect the electromagnetic signal generated by the Beacon transponders and track the target in real time throughout the SBRT treatment.

**Transponder implantation**

Three Anchored Beacon transponders were implanted via electromagnetic navigational bronchoscopy (ENB) by an interventional pulmonologist based on a thin-slice planning CT scan. The transponders were securely anchored to the airway wall by a five-legged stability feature that self-expanded upon deployment. This helped to prevent migration of the transponders during and following treatment.

**Treatment delivery**

Prior to treatment the patient was coached on DIBH by holding air in his lungs for 20 seconds and repeating the exercise 5 times to ensure he could adequately hold his breath. During treatment the patient was prompted through audio control to perform breath holds when the radiation beam was on. This technique helped to limit radiation exposure to healthy organs.

Treatment consisted of 50 Gy delivered in 5 fractions using a coplanar beam arrangement on the TrueBeam® system with RapidArc® radiotherapy technology. Breath hold cone beam CT (CBCT) was obtained prior to and during treatment to ensure reproducibility of the target position. kV images were also used for additional verification.

Throughout the course of treatment, clinicians were able to observe variable target motion in real-time. The radiation beam automatically paused when the target position moved outside the set tolerance. The Set Zero and Track capability was used to adjust the tolerance by redefining the zero point for tracking after setup was finalized based on an independent setup method, such as imaging. This can be helpful for transponder registration and target-to-target registration based on image matching.

"In our experience, we have observed marked differences in tumor position, DIBH level, and respiratory excursion from fraction to fraction and patient to patient. We would not have been able to see these variabilities without Calypso giving us real-time positional information," said Dr. Rimner.

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Memorial Sloan Kettering Cancer Center (MSK) — the world’s oldest and largest private cancer center — has devoted more than 130 years to exceptional patient care, innovative research, and outstanding educational programs. Today, MSK is one of 45 National Cancer Institute–designated Comprehensive Cancer Centers, with state-of-the-art science flourishing side by side with clinical studies and treatment.
Conclusion

The patient completed treatment successfully without significant side effects related to radiation or implantation of the Beacon transponders. Tumor control was achieved in the area that was treated with SBRT.\(^5\)

The use of Calypso enabled effective monitoring of the tumor during treatment to maximize the delivery of radiation to the tumor site and minimize side effects from radiation. This is especially important in patients with medically inoperable early stage NSCLC who have had prior surgeries, where minimizing damage to healthy lung tissue, preserving remaining lung function, and accurately targeting the delivery of radiation to the tumor site are high priorities.

"The real benefit that we see with Calypso is that we can monitor the tumor position in real time and ensure precise targeting, minimizing the target volume as well as the lung volume that gets irradiated," said Dr. Rimner.

"Combining Calypso with deep inspiration breath hold was really helpful in this case because the targeted lesion was located close to the proximal bronchial tree, a very sensitive structure, and we were able to reduce treatment margins and enable the maximum radiation dose to be delivered to the target while sparing healthy tissue and organs. We wouldn’t have been able to achieve these results with any other method."

5. For full study results, please consult MSKCC.