Stereotactic Body Radiation Therapy for Treatment of Primary and Metastatic Pulmonary Malignancies

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KEYWORDS

• Stereotactic body radiation therapy • Stereotactic ablative radiotherapy
• Lung cancer • Pulmonary metastases • Surgery

KEY POINTS

- Stereotactic body radiation therapy (SBRT) is an effective treatment for medically inoperable stage I non–small cell lung cancer with local control achieved in approximately 90% of patients.
- Most patients tolerate treatment exceptionally well. As high doses of radiation therapy are used, care is necessary when treating tumors that are located near the brachial plexus, primary tracheobronchial tree, skin, or chest wall. SBRT is currently being compared with surgery in randomized trials.
- SBRT has also been used for limited pulmonary metastases and studies are ongoing to determine the optimal method of integrating SBRT with systemic therapy.

INTRODUCTION

A conventional course of radiation therapy for most epithelial malignancies consists of daily treatments over a period of approximately 6 to 8 weeks. Stereotactic radiosurgery (SRS) has been successfully used for many years to manage both benign and malignant intracranial tumors. SRS contrasts dramatically with conventional radiation therapy. Instead of small daily fractions over many weeks, a single large treatment is precisely administered to a target while minimizing the dose to surrounding tissues. This approach has been adapted for extracranial targets whereby either a single or small number of dose-intense treatments are given over a 1- to 2-week period.[1] This technique is commonly referred to as both stereotactic body radiation therapy (SBRT) and stereotactic ablative radiotherapy.

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Because SBRT consists of large radiation doses, which are associated with a greater potential for local tumor control but also normal tissue complications, with the radiation dose highly conformal to the target (making precise delivery critical), 3 components are mandatory for the successful and safe implementation of SBRT. The first component is reproducible and comfortable patient immobilization to prevent movement during the radiation treatment. This immobilization is most commonly performed using a Styrofoam (The Dow Chemical Company, Midland, Michigan) mold, vacuum bag, or a body frame. The second component is the assessment of respiratory-induced motion. Liver and lung tumors, in particular, are not stationary during the respiratory cycle and their motion must be taken into account during both the planning and treatment phase. Numerous strategies have been implemented to minimize and/or account for this. The third component includes the ability to image the tumor immediately before the treatment to ensure that the target and radiation dose distribution are aligned properly. This process is termed image-guided radiation therapy and is typically performed with computed tomography (CT) imaging or with implanted fiducial markers.

SBRT has emerged as an attractive, and potentially more effective, alternative to conventional radiation therapy for a variety of malignancies. Numerous prospective studies have evaluated SBRT for medically inoperable stage I non–small cell lung cancer (NSCLC). For most other malignancies, the data remains preliminary, although numerous prospective studies are currently ongoing. SBRT is being formally investigated for prostate cancer, pancreatic cancer, breast cancer, painful bone metastases, and liver and lung oligometastases, to name just a few. This article aims to summarize the data on SBRT, with a particular focus on stage I lung cancer and pulmonary metastases.

SBRT: STAGE I NSCLC

Surgery remains the preferred treatment modality for stage I NSCLC. However, patients with lung cancer often present with serious medical comorbidities, often related to tobacco abuse, which make them high-risk operative candidates. Many such patients are observed and do not receive any cancer-directed treatment.[2,3] Despite their other comorbidities, most patients who are observed eventually die of lung cancer.[4] Many other patients have minimal pulmonary reserve and undergo sublobar resections (eg, wedge resection), which are associated with a higher risk of local disease recurrence.[5–10] Other patients, particularly the elderly, wish to avoid surgery and seek out less-invasive alternatives.

Historically, conventional radiation therapy was the treatment of choice for patients with inoperable stage I NSCLC. The typical treatment was 60 to 66 Gy in 1.8- to 2.0-Gy daily fractions. Although this was generally well tolerated, 5-year survival was poor (~15%), with approximately 25% to 50% of tumors recurring at the treated site.[11–15] The primary reason for such a high risk of treatment failure may have been an inadequate radiation dose. Therefore, beginning in the early 1990s, investigators from around the world began exploring SBRT as an alternative approach. Biologically, a few very large treatments are more potent than many small treatments, even when the total radiation dose is the same. Furthermore, multiple radiation fields from different directions are used in SBRT. This method helps create a dose distribution that is conformal to the target, limiting the high dose to surrounding tissues and allowing for the safer administration of larger radiation doses (**Figs. 1** and **2**).

The first phase I dose-escalation study was performed by Robert Timmerman and colleagues[16] at Indiana University. Eligible patients were required to have stage I