Treatment Planning for Radiation Therapy

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KEYWORDS

• Lung cancer • PET • CT scanning • Radiation therapy • Surgery • Chemotherapy

KEY POINTS

- ^{18}F-fluorodeoxyglucose (FDG)–PET scanning is an essential part of the pretreatment evaluation for patients with lung cancer who are candidates for curative-intent radiation therapy.
- PET data are critical to the radiation treatment planning process and contemporary images acquired on a combined PET/computed tomography scanner in the radiotherapy treatment position are the ideal images for target volume delineation in patients with locoregionally advanced disease.
- Response-adapted therapy, based on PET images acquired during the treatment course, is a promising experimental approach.
- Although metabolic tumor imaging with FDG remains the standard approach, imaging of proliferation and hypoxia with alternative tracers may give additional information.
- Uptake of FDG in irradiated normal tissues may have application in the diagnosis and management of radiation-induced toxicity.

INTRODUCTION

Treatment planning for patients with lung cancer who are candidates for potentially curative radiation therapy (RT) is a broad topic that encompasses many factors, including staging, selection of appropriate patients, and target volume definition. In all of these critical areas, imaging plays a central role.[1] Although ^{18}F-fluorodeoxyglucose (FDG)–PET imaging is currently the most important modality for staging disease extent and for defining the target volume for patients with lung cancer who are treated with RT,[2] many other factors should be considered important when deciding between surgery or an attempt at potentially curative RT or a less aggressive palliative treatment regimen. As stereotactic ablative RT (SABR)[3] has become more widely used for potentially curative treatment of small lung tumors and oligometastases (**Fig. 1**), the interface between surgery and RT has become more complex and controversial.

With advances in the systemic treatment of lung cancer, such as targeted therapies including epidermal growth factor receptor (EGFR) tyrosine kinase inhibitors (TKIs),[4] novel indications for RT are being pioneered. For example, after a good initial treatment response to TKI, patients with oligoprogressive disease may respond to local RT and continue to benefit from their systemic therapy at other disease sites that remain controlled (**Fig. 2**). Accurate imaging is important in such cases to ensure that disease progression is truly localized. As treatment paradigms become more complex, the integration of imaging into the overall management of the patient becomes more subtle and refined. This

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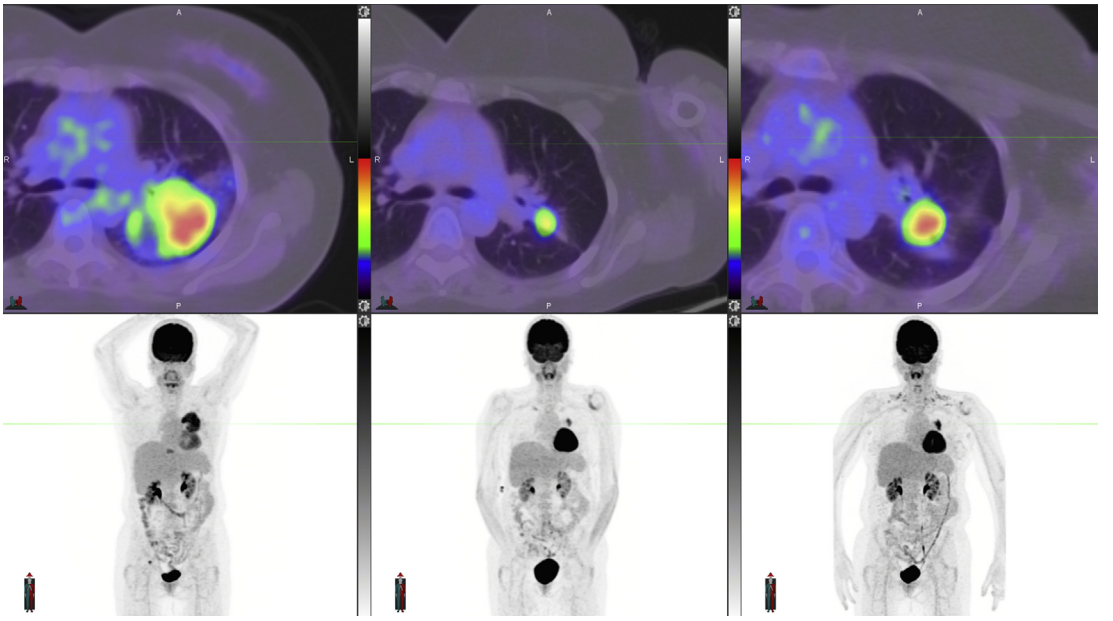

Fig. 1. Role of radiation in a patient treated with targeted therapy. Sequential FDG-PET/computed tomography (CT) (*top row*) and PET (*bottom row*) images for a patient with stage epidermal growth factor receptor (EGFR) mutation–positive stage IV NSCLC. On the 2 left images, a painful metastasis at T9 and the left lower lobe primary tumor can be observed. The 2 middle images, performed 19 months later, after local irradiation at T9 and with ongoing anti-EGFR tyrosine kinase inhibitor (TKI) therapy, show an ongoing complete response at the site of irradiation and an excellent partial response in the primary tumor. After a further 3 months (2 right images), there is continuing disease control at the irradiated site but progression in the primary tumor.

article focuses on non–small cell lung cancer (NSCLC) rather than small cell lung cancer (SCLC) because the literature is much larger and more conclusive for this group of diseases, although the role of FDG-PET scanning in SCLC is becoming better established because of the high incremental value of PET imaging in this more aggressive but less common cancer.

WHAT PATIENTS ARE SUITABLE FOR CURATIVE-INTENT RADIATION THERAPY?

Disease-Related Factors

In general, patients who have NSCLC that can be resected without a high risk of death or severe morbidity are recommended to have surgery. Curative surgery generally involves a lobectomy or pneumonectomy and mediastinal lymph node dissection but in selected small T1 tumors a more limited sublobar resection may be considered. Stage I and II patients may not be fit for surgery because of comorbidities such as lung or heart disease but may still be eligible for curative-intent RT. Selected patients with T1 and T2 tumors that are located 2 cm or more beyond the major airways may be suitable for SABR, in which an extremely high ablative RT dose is delivered by multiple narrow noncoplanar beams in a small number of very-high-dose fractions (or a single fraction). In appropriately selected patients, local disease control is very high (around 90%) after SABR and survival may be comparable with surgery. More centrally located T1 tumors are more safely treated with conventionally fractionated RT.

In contrast with earlier stage disease, most patients with stage III NSCLC are better served by radical concurrent platinum-based chemoradiation with curative intent rather than by surgery, and for these patients long-term survival rates have increased incrementally in recent years, in large part because of the use of PET for patient selection. In the special case of limited stage IIIA disease with single nodal station and potentially resectable N2 disease there is continuing controversy around the use of surgery after neoadjuvant therapy with induction chemotherapy or after induction chemoradiation. Trimodality therapy may provide superior local disease control for patients who have stage IIIA disease amenable to resection by lobectomy. However, it is not clear that overall survival is improved compared with chemoradiation alone.