

**Case
Report**

Thoracoscopic Lobectomy as Salvage Surgery for Local Recurrence of Non-Small Cell Lung Cancer after Carbon Ion Radiotherapy in an Initially Operable Patient

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Carbon ion radiotherapy (CIRT) for patients with early-stage non-small cell lung cancer (NSCLC) has recently provided favorable local control with very few toxic reactions. Because CIRT for NSCLC has been mostly performed for elderly or inoperable patients, salvage surgery for NSCLC after CIRT has rarely been reported. We describe a case of complete thoracoscopic right upper lobectomy with mediastinal lymphadenectomy performed as salvage surgery for local recurrence of stage IA NSCLC after CIRT in an initially operable patient who had refused surgery 27 months previously. Pleural adhesions caused by CIRT were localized to the pulmonary apex and the central pulmonary structures were intact at the time of the salvage surgery, which allowed us to successfully perform thoracoscopic lobectomy without any complications. Thus, salvage surgery for NSCLC after CIRT may be feasible in an initially operable patient, as CIRT appears to be unlikely to cause any difficulties in the salvage surgery.

Keywords: lung cancer, salvage therapy, thoracoscopy, radiotherapy, heavy ion radiotherapy

Introduction

Carbon ion radiotherapy (CIRT) has the potential to provide a sufficient radiation dose to the tumor, while

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producing an acceptable level of damage to the surrounding normal tissues.¹⁾ CIRT for patients with early stage non-small cell lung cancer (NSCLC) has been reported to provide favorable local control with very few toxic reactions.¹⁾ Recently, cases of local recurrence of stage I NSCLC after CIRT have been reported, necessitating repeat CIRT, linac irradiation or chemotherapy as salvage therapy.²⁾ However, salvage surgery for NSCLC after CIRT has rarely been reported, because CIRT for NSCLC has mostly been performed for elderly or inoperable patients. Herein, we describe a case of thoracoscopic lobectomy performed as salvage surgery for local recurrence of stage IA NSCLC after CIRT in an initially operable patient.

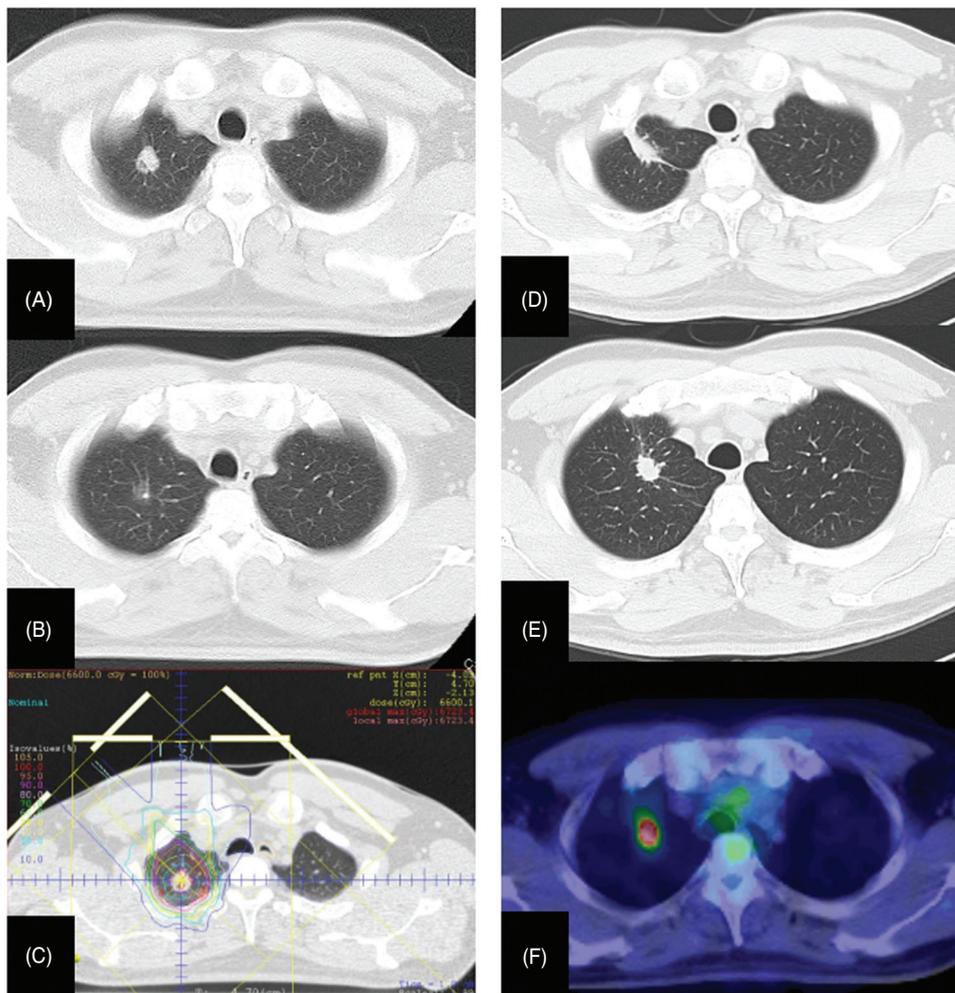


Fig. 1 Chest computed tomography (CT) at the time of the carbon ion radiotherapy (CIRT) showed an apical tumor in the right upper lobe (A) and a ground-glass opacity at the caudal side of the primary tumor (B). (C) Radiation isodose distribution at the CIRT. Chest CT 27 months after CIRT demonstrated a scarred tumor (D) and a new tumor arising adjacent to the caudal side of the scarred tumor (E). (F) ^{18}F -Fluorodeoxyglucose-positron emission tomography (FDG-PET) 27 months after CIRT revealed high FDG uptake only in the new tumor.

Case Report

A 41-year-old man was referred to our hospital for the treatment of local recurrence of a lung adenocarcinoma at 27 months after CIRT. In regard to the initial treatment, the patient had refused surgery for clinical stage IA NSCLC and undergone CIRT at 66 Gray equivalents in 10 fractions, according to the treatment protocol,²⁾ for a right apical adenocarcinoma measuring 15 mm in diameter. The primary tumor mainly consisted of a solid component, but also manifested as a small ground-glass opacity (GGO) at the caudal side of the tumor (Fig. 1A

and 1B). At the time of the CIRT, the planning target volume had been set up with a margin of 5 mm and an internal margin of 1 mm to the clinical target volume, corresponding to the gross tumor volume plus a margin of 5 mm in all directions (Fig. 1C). Chest computed tomography (CT) 27 months after CIRT showed a new 20-mm tumor arising adjacent to the caudal side of the scarred tumor (Fig. 1D and 1E). ^{18}F -Fluorodeoxyglucose-positron emission tomography (FDG-PET) revealed high FDG uptake only in the new tumor, with a maximum standardized uptake value of 7.9 (Fig. 1F). Image analysis revealed no evidence of distant metastasis. Because the pulmonary function test results of the patient were normal even after

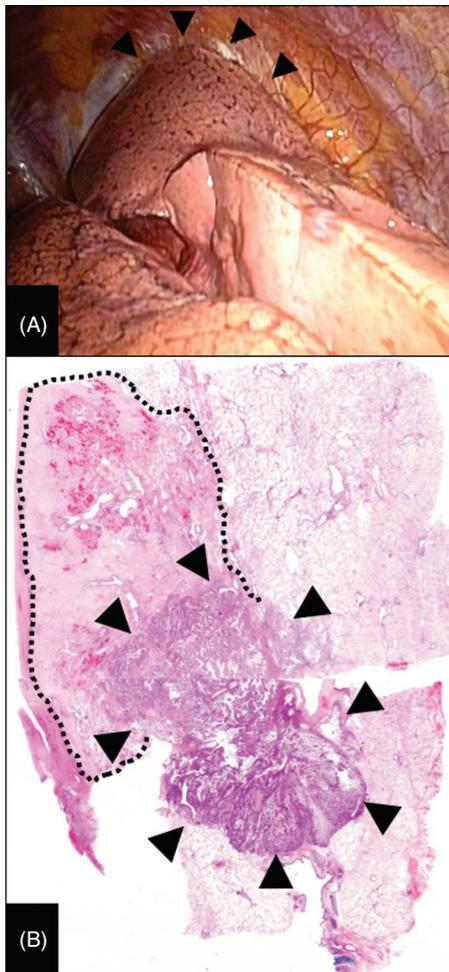


Fig. 2 (A) Intraoperative photograph of pleural adhesions localized to the right pulmonary apex (arrowhead). (B) Loupe view showing a well-demarcated tumor (arrowhead) adjacent to the fibrotic tissue (dashed-line area).

the CIRT, we performed complete thoracoscopic right upper lobectomy with mediastinal lymphadenectomy. The 11-mm thoracoport for a 10-mm, 30° thoracoscope was placed in the 7th intercostal space on the mid-axillary line. The 35-mm and the 25-mm windows were placed in the 4th intercostal space on the anterior axillary line and in the 6th intercostal space on the posterior axillary line, respectively. Silicon rubber instruments (Alexis Wound Protector/Retractor X-Small; Applied Medical, Rancho Santa Margarita, California USA) were applied to these windows, so that both the operator and the assistant could use two surgical instruments through these windows. Local pleural adhesions between the right pulmonary

apex and the chest wall resulting from the CIRT were successfully dissected under thoracoscopic guidance (**Fig. 2A**). There were no apparent CIRT-related changes of the pulmonary structures, and dissection around the vessels and bronchi was performed without any difficulties. Endoscopic linear staplers were used for division of the right superior pulmonary vein, the first branch of the right pulmonary artery (A1+3), the right upper lobe bronchus and the interlobar fissure. Other branches of the right pulmonary artery (A2a, A2b) were ligated. The bronchial stump was not covered by any tissue following the lobectomy. The total blood loss was 150 ml, and the operative time was 318 min. A total of 20 lymph nodes were dissected. There were no complications during the surgery, and the chest tube was removed on the second postoperative day. Pathological examination of the resected specimen revealed papillary adenocarcinoma with a single upper lobar nodal metastasis. The viable tumor nest measuring 24 mm was located adjacent to the post-therapeutic fibrotic tissue, indicating marginal recurrence (**Fig. 2B**). The patient had an uneventful postoperative course, and received postoperative adjuvant chemotherapy.

Discussion and Conclusion

To the best of our knowledge, this is the first report of thoracoscopic lobectomy performed as salvage surgery for NSCLC after CIRT. Because the irradiated area in CIRT was confined to the peripheral lung, the pleural adhesions were localized to the pulmonary apex and the central pulmonary structures were intact after the CIRT, which allowed us to successfully perform thoracoscopic lobectomy without any complications, including during the postoperative period. CIRT is not likely to cause difficulties in salvage surgery, similar to the case in stereotactic body radiotherapy (SBRT), as compared to conventional radiotherapy,³⁾ suggesting that salvage surgery for NSCLC after CIRT may be feasible in an initially operable patient.

The microscopic findings in our patient implied that the relapse pattern was marginal recurrence rather than infield recurrence,⁴⁾ even though a sufficient margin around the tumor had been set for the CIRT. While our single case is not enough for a discussion of the risk factors for local recurrence after CIRT, our case suggested that we should be careful while treating GGO lesions by radiotherapy. Importantly, Grills, et al. reported that microscopically, the tumor cells in GGO lesions extended beyond the visually identified GGO area.⁵⁾ Because CIRT provides sharp

distal falloff of the radiation dose and has a smaller penumbra as compared to SBRT, meticulous care for setup correction might be required to improve the local control of tumor corresponding to a GGO lesion. Further accumulation of cases of salvage surgery for NSCLC after CIRT is required for a more detailed evaluation.

Disclosure Statement

None of the authors has any financial or other potential conflicts of interest.

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