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Original Report

Minimally invasive rib-sparing video-assisted thoracoscopic surgery resections with high-dose-rate intraoperative brachytherapy for selected chest wall tumors

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Abstract

Background: By avoiding chest wall resection, iridium-192 (Ir-192) high-dose-rate (HDR) intraoperative brachytherapy (IOBT) and video-assisted thoracoscopic surgery (VATS) might improve outcomes for high-risk patients requiring surgical resection for pulmonary malignancy with limited pleura and/or chest wall involvement.

Methods and materials: Seven patients with non-small cell lung cancer involving the pleura or chest wall underwent VATS pulmonary resections combined with HDR IOBT. After tumor extraction, an Ir-192 source was delivered via a Freiburg applicator to intrathoracic sites with potential for R1-positive surgical margins. The number of catheters, dwell position along each catheter, prescription depth, and dose were customized based on clinical needs.

Results: Six patients had pT3N0M0 non-small cell lung cancers. A seventh case was a recurrent sarcomatoid carcinoma. One case required conversion to open thoracotomy for pneumonectomy with en bloc chest wall resection. There were no intraoperative complications and average operative time was 5.8 hours. Five of seven patients without transmural chest wall involvement underwent rib-sparing resection. Four of the 6 patients treated with VATS and IORT remain alive in follow-up without evidence of local recurrence (median follow-up, 25 months). Noted toxicities were recurrent postoperative pneumothorax, pleural effusion with persistent chest wall pain, avid fibrosis at 2 years of follow-up, and a late traumatic rib fracture.

Conclusions: HDR IOBT with Ir-192 via VATS is technically feasible and safe for intrathoracic disease with pleural and/or limited chest wall involvement. Short-term morbidity associated with chest wall resection may be reduced. Additional study is required to define long-term benefits.

Conflicts of interest: All authors of this manuscript and all contributors from the Department of Radiation Medicine and the Department of Thoracic Oncology at Roswell Park Cancer Center deny any conflicts of interest with any contents of this manuscript or its publication.

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Introduction

Combined lung and chest wall resection carries a high risk for morbidity and mortality. The optimal management for patients with locally invasive or large aggressive non-small cell lung cancer (NSCLC) is challenging, and controversy exists regarding the timing and effectiveness of various treatment modalities, patient selection criteria, and extent of surgical resection (extrapleural vs en bloc rib resection). Overall and disease-free survival with traditional therapy remains suboptimal; however, advanced individualized techniques and technology offer the promise of improved local control and overall survival. Improved delivery using less toxic or invasive techniques may decrease morbidity and mortality for patients with dangerous comorbidities. (See Figs. 1 and 2.)

When feasible, surgery remains the treatment of choice for localized NSCLC, with favorable 5-year survival rates of 65% to 70% in this operable cohort.[1,2] However, external beam radiation therapy and concurrent chemoradiation therapy are often recommended for patients with potentially resectable disease resulting from poor pulmonary function, medical comorbidities, or anatomic restrictions, such as chest wall invasion, rendering patients poor surgical candidates. This therapy is toxic, requires 6 weeks for delivery combined with several weeks of recovery, produces suboptimal local control, and often constrains the dosing of concurrent systemic therapy.[3] For patients that are acceptable candidates for resection, surgical morbidity and mortality can be significant. Recently published results from a large multi-institutional database demonstrate outcomes for patients undergoing lobectomy with combined chest wall resections that approach that of pneumonectomy.[4]

Previously reported results from Memorial Sloan Kettering Cancer Center demonstrated a significant improvement in locoregional control and a 9% improvement in 5-year survival with the addition of intraoperative brachytherapy (IOBT) after resection of superior sulcus tumors via open thoracotomy.[5] The American Brachytherapy Society released a consensus guideline for thoracic brachytherapy in 2016 that discusses the intraoperative use of single-fraction, high-dose-rate (HDR) brachytherapy boosts after resection with doses of 10 to 15 Gy and the benefits of organ shielding and displacement used. However, the guidelines also highlighted a current lack of substantial literature about this technique, along with an encouragement for prospective data collection.[6]

In an attempt to reduce treatment-related morbidity and mortality in select cases, we began using HDR IOBT for select pT3N0-1 tumors with limited chest wall involvement, in conjunction with a minimally invasive surgical approach. After incorporating minimally invasive video-assisted thoracoscopic surgery (VATS) for early stage lung malignancies over the course of a decade while maintaining comparable pathologic and oncologic outcomes, we began to expand our indications for VATS to patients with locally advanced disease. Patients with larger tumors, neoadjuvant therapy, N1 or N2 disease, and even with chest wall invasion were approached by VATS with increasing levels of success. In carefully selected patients, IOBT was used intraoperatively for patients with pleural involvement, or limited chest wall invasion. This technique has not been reported in the current literature to our knowledge, and this report describes our experience, techniques, and outcomes with this novel combination therapy.

Methods

Case overview

From January 2012 through December 2015, 7 patients with thoracic malignancies involving the pleura and/or chest wall underwent VATS pulmonary resections with HDR IOBT. Individual patient characteristics and case details are provided in Figure 1. One case required conversion to an open thoracotomy with transition from a planned lobectomy to a pneumonectomy because of the extent of disease. During this period, approximately 7 surgical chest wall resections per year were being performed at our institution. VATS was used for the majority of the NSCLC cases. Additionally, more than 200 patients with locally advanced NSCLC were treated with definitive radiation or chemoradiation therapy, with one-half of these patients having been deemed medically operable.

One case was a recurrent sarcomatoid lung carcinoma. The other 6 lesions treated were clinically staged as T2-3N0-1 NSCLC of squamous cell or adenocarcinoma histology. Two lesions were left-sided and 5 were right-sided. Five of the 7 patients had apical lesions. All patients underwent neoadjuvant radiation therapy at a dose of 45 Gy with concurrent chemotherapy, except for 1 with NSCLC who underwent induction chemotherapy. Dose exceptions occurred in 1 NSCLC patient (50.4 Gy from outside facility) and the recurrent sarcomatoid case (60 Gy 2 years earlier as part initial definitive therapy). Adjuvant chemotherapy was used routinely, if tolerated. One patient died of brain metastases before completion of adjuvant therapy, and systemic therapy was withheld in 1 patient because of poor performance status.

Physics

A MicroSelectron HDR unit (model digital V3, Manufacturer Elekta Inc.) was used for dose delivery in a specially designed shielded operation room. This unit uses a 10 Ci miniaturized iridium-192 (Ir-192) source of the size of around 1 mm in diameter and around 5 mm in length.