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BRACHYTHERAPY

High- and low-dose-rate intraoperative radiotherapy for thoracic malignancies resected with close or positive margins

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ABSTRACT

PURPOSE: Local recurrence is a significant problem after surgical resection of thoracic tumors. As intraoperative radiotherapy (IORT) can deliver radiation directly to the threatened margin, we have used this therapy in an attempt to reduce local recurrence, using high-dose-rate (HDR) as well as low-dose-rate (LDR) techniques.

METHODS AND MATERIALS: We performed a retrospective review of patients undergoing LDR (^{125}I) mesh placement or HDR (^{192}Ir) afterloading therapy during lung tumor resection between 2001 and 2013 at our institution. Competing risks methods were used to estimate the cumulative incidence of local failure. We also assessed possible predictive factors of local failure.

RESULTS: Fifty-nine procedures (41 LDR and 18 HDR) were performed on 58 patients. Median follow-up was 55.1 months. Cumulative incidence of local failure at 1, 2, and 3 years was 28.5%, 34.2%, and 34.2%, respectively. Median overall survival was 39.9 months. There was no significant difference in local failure according to margin status, HDR vs. LDR, use of adjuvant external beam radiotherapy, or metastatic vs. primary tumor. Two patients (3.4%) experienced Grade 3+ toxicities likely related to brachytherapy. Additionally, 7 patients experienced Grade 3+ postsurgical complications unlikely related to brachytherapy.

CONCLUSIONS: IORT is associated with good local control after resection of thoracic tumors otherwise at very high risk for local recurrence. There is a low incidence of severe toxicity attributable to brachytherapy. HDR-IORT appears to have equivalent outcomes to LDR-IORT. HDR or LDR-IORT can, therefore, be considered in situations where the oncologic completeness of thoracic tumor resection is in doubt.

Keywords: Intraoperative radiotherapy; High-dose rate; Thorax

Introduction

Thoracic tumors are generally managed surgically when the primary goal of treatment is durable local control. However, complete resection of the tumor is not always possible, and in cases where the surgical margin is known or presumed to be positive, adjuvant treatments are often prescribed to reduce the likelihood of local recurrence. Options for adjuvant treatment include systemic therapy and radiotherapy (RT). If RT is used, external beam radiotherapy (EBRT) is the most common technique.

However, intraoperative radiotherapy (IORT) is an alternative to EBRT with unique practical and dosimetric

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benefits. Rapid dose falloff allows for high dose to the threatened margin with minimal dose to the additional normal tissue. Patients who have previously received a course of EBRT to the same or nearby site may not be candidates for more EBRT due to normal tissue tolerances, and brachytherapy may be the only option for adjuvant RT. Additionally, the difference in treatment length is substantial. Although a course of adjuvant EBRT may take 4–6 weeks to complete, IORT only requires that the operation be extended by 1 or 2 h.

At our institution, IORT in the thorax has been performed either by low-dose-rate (LDR) permanent implantation of a mesh containing ^{125}I seeds, or by high-dose-rate (HDR) temporary application of afterloaded ^{192}I. In recent years, HDR-IORT has become the more common method of thoracic IORT at our institution.

To date, there are extremely limited data on the use of HDR-IORT in the thorax, with only one report consisting of 6 patients (1). Existing reports on the use of LDR-IORT in the lung have shown mixed results. A recent prospective trial comparing sublobar resection vs. sublobar resection with LDR ^{125}I implants for early-stage non-small cell lung cancer (NSCLC) found no significant increase in Grade ≥3 adverse events but also no significant benefit in local control (2, 3). Published studies on intraoperative LDR implants in advanced thoracic malignancy have generally reported low incidence of toxicity with high rates of local control, and further investigation was, therefore, encouraged (4, 5). Because of the paucity of contemporary literature regarding the safety and efficacy of thoracic IORT, in particular with HDR-IORT, we sought to review our institution's experience with these techniques to further elucidate their risks and benefits.

Methods and materials

Patient selection

Institutional review and privacy boards approved this study, and patient confidentiality was maintained as required by the Health Insurance Portability and

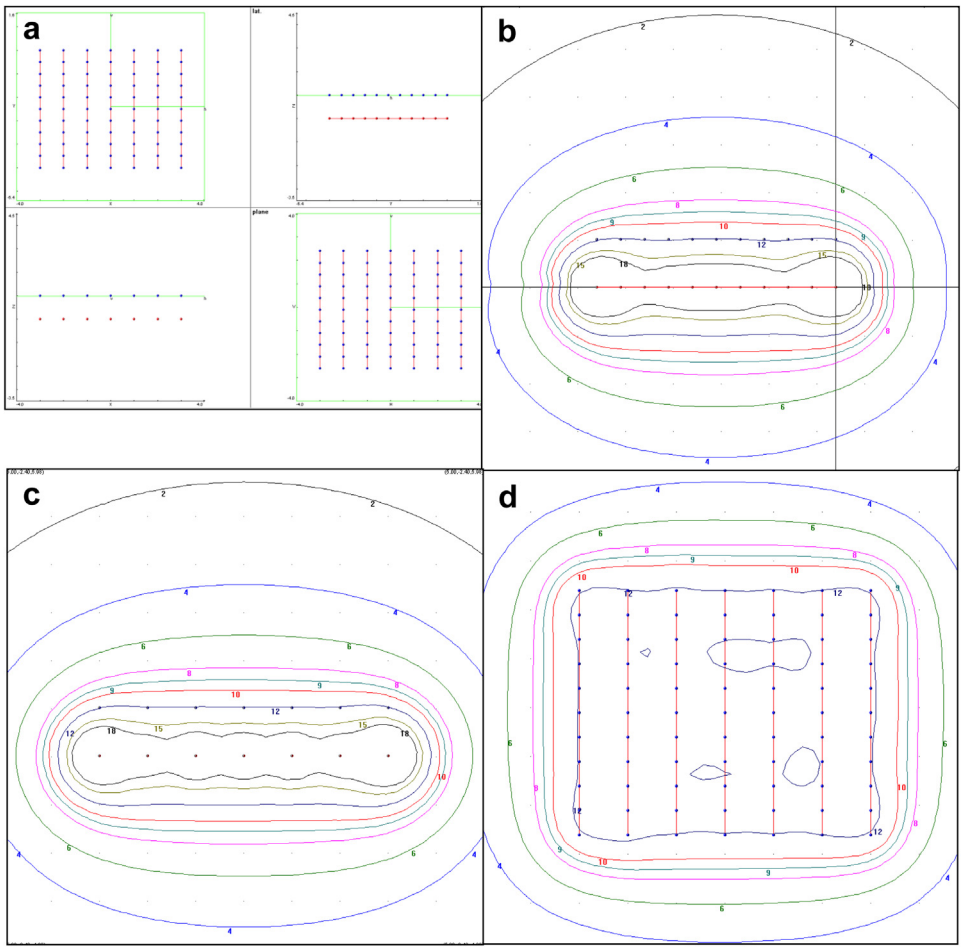

Fig. 1. HDR dosimetry. A 6 × 5 cm (7 channels × 11 dwell positions) implant is shown. Source channels are depicted in red and prescription plane points are shown in blue. 12 Gy were prescribed using an Atlas based plan to 1 cm from the source (5 mm from the surface of the HAM applicator). Panel (a) shows the treatment geometry, panels (b) and (c) show the sagittal, axial isodose through the center of the applicator, and panel (d) shows the isodose distribution in the coronal prescription plane (5 mm from the surface of the applicator). HDR = high-dose rate; HAM = Harrison–Anderson–Mick. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)