



Research Article

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Evaluation of Target Definition for Reirradiation of Recurrent Pancoast Tumors



Ferrat Dincoglan, Selcuk Demiral*, Omer Sager and Murat Beyzadeoglu

Department of Radiation Oncology; University of Health Sciences, Gulhane Medical Faculty, Ankara, Turkey

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Corresponding author: Selcuk Demiral, Department of Radiation Oncology; University of Health Sciences, Gulhane Medical Faculty, Ankara, Turkey

Abstract

Objective: Accurate target delineation is essential for successful reirradiation in anatomically complex regions such as the thoracic inlet. This study evaluates the role of multimodal imaging—specifically magnetic resonance imaging (MRI) co-registered with computed tomography (CT)—in refining target volume definition for patients undergoing reirradiation for recurrent Pancoast tumors.

Materials and Methods: Patients with locally recurrent Pancoast tumors who had received prior thoracic radiation were included. All patients were candidates for reirradiation based on disease extent, performance status (ECOG 0–2), and a multidisciplinary evaluation. CT-based simulation was performed using custom immobilization in supine position to optimize reproducibility. MRI sequences (T1, T2, contrast-enhanced) were acquired and co-registered with planning CT images. Initial target volumes were delineated based on CT alone and subsequently refined using MRI input.

Results: Contouring was performed by board-certified radiation oncologists with expertise in thoracic reirradiation. Key imaging considerations included the identification of recurrent target volume, proximity to the brachial plexus, subclavian vessels, and vertebral bodies, and differentiation between recurrence and post-treatment fibrosis. MRI refinement altered target delineation in most cases. CT-based contours often overestimated target volume due to inclusion of fibrotic tissue or adjacent vascular structures and underestimated disease extent when recurrence extended into soft tissue planes obscured by prior radiation changes. MRI-guided refinement resulted in more precise margins, especially near the brachial plexus and thoracic vertebrae. Composite planning demonstrated that MRI-based contours allowed improved target definition for optimal reirradiation.

Conclusion: MRI-assisted target delineation enhances anatomical accuracy and dosimetric quality in reirradiation of recurrent Pancoast tumors. In anatomically constrained areas with prior radiation, soft tissue contrast provided by MRI is invaluable for distinguishing tumor recurrence from fibrosis or post-surgical changes. Incorporating MRI into reirradiation planning should be considered routine for thoracic inlet recurrences.

Keywords: Reirradiation; Pancoast tumor; Target delineation; MRI-CT fusion; Thoracic inlet

Abbreviations: SCLC: Small Cell Lung Cancer; IMRT: Intensity-Modulated Radiotherapy; stereotactic techniques, ART: Adaptive Radiotherapy; CT: Computed Tomography; MRI: Magnetic Resonance Imaging; AAPM: Association of Physicists in Medicine; ICRU: International Commission on Radiation Units and Measurements; HU: Hounsfield Units

Introduction

Pancoast tumors, arising at the lung apex, pose unique clinical challenges due to their proximity to critical neurovascular and musculoskeletal structures including the brachial plexus, subclavian vessels, vertebral bodies, and upper thoracic spine. These tumors often require multimodal treatment consisting of chemoradiation and surgery [1-7]. However, local recurrence remains a considerable clinical problem, and reirradiation may be

considered in selecting patients who are not surgical candidates or who decline surgery.

Given the anatomical complexity and prior radiation exposure, the process of target definition in the reirradiation setting is nuanced, and there is no consensus regarding optimal contouring approaches for recurrent Pancoast tumors. This study aims to evaluate target definition strategies for patients who underwent

reirradiation of recurrent Pancoast tumors with a focus on contouring practices. By analyzing data and treatment planning metrics, we seek to highlight key challenges and propose potential contouring principles to guide future practice.

Materials and Methods

We identified patients treated at our institution with a diagnosis of recurrent Pancoast tumors who received a second course of radiotherapy. Selected patients had a histologically or radiographically confirmed local recurrence at the apex of the lung after prior radiation therapy, and planning data from both initial and reirradiation courses. Simulation for reirradiation was performed using Computed Tomography (CT) with or without contrast.

Magnetic Resonance Imaging (MRI) scans were fused to assist with target delineation. Prior treatment plans were imported and fused using deformable registration when available. We recorded the size and location of recurrent tumors, target volumes, and their relation to prior treated volumes. Doses to organs-at-risk (OARs) including spinal cord, brachial plexus, lungs, esophagus, and trachea were considered. figure 1

Results

Patients included in this study had histologically or radiographically confirmed local recurrence in the lung apex following prior radiation therapy, along with available planning data from both the initial and reirradiation courses. CT-based simulation was performed with patients immobilized in the supine position. MRI—both standard and contrast-enhanced sequences—was acquired and co-registered with CT scans to enable multimodal image fusion. Initial target volumes were delineated on CT alone and subsequently refined using MRI input by experienced radiation oncologists.

Reirradiation plans were generated using institutional treatment planning systems and delivered via linear accelerator (LINAC) with daily cone-beam CT for image guidance. Dose prescriptions aimed to cover at least 95% of the target volume while respecting organ-at-risk (OAR) constraints in accordance with QUANTEC and AAPM guidelines. Integration of MRI into the contouring process influenced target definition in most cases. CT-based planning alone sometimes resulted in over-contouring due to the inclusion of adjacent non-target tissues, while under-contouring also occurred in certain cases. Overall, the incorporation of MRI led to a reduction in target volumes and enhanced anatomical precision.

Discussion

Pancoast tumors, located at the apex of the lung, present distinct clinical challenges due to their proximity to critical neurovascular and musculoskeletal structures such as the brachial plexus, subclavian vessels, vertebral bodies, and upper thoracic

spine. These tumors are typically managed with a multimodal approach including chemoradiation followed by surgical resection [1-7]. Despite aggressive treatment, local recurrence remains a significant concern. For patients who are not surgical candidates or who decline surgery, reirradiation may offer a potential treatment option. However, the complexity of the anatomy and the presence of prior radiation exposure make target delineation in the reirradiation setting particularly challenging.

Currently, there is no standardized consensus on optimal contouring strategies for recurrent Pancoast tumors. Our study aimed at evaluating target delineation strategies in patients who underwent reirradiation for recurrent Pancoast tumors, with a specific focus on contouring practices. By analyzing imaging and planning data, we sought to identify key challenges and propose guiding principles that may inform future clinical practice. We identified patients with recurrent Pancoast tumors treated with a second course of radiation therapy at our institution. Eligible patients had histologically or radiographically confirmed recurrence at the lung apex after prior radiation, and both initial and reirradiation planning data were available for analysis.

Simulation for reirradiation was performed using CT with or without intravenous contrast, with patients immobilized in the supine position. MRI, including standard and contrast-enhanced sequences, was acquired and fused with the planning CT to assist with target delineation. When accessible, prior treatment plans were incorporated into the planning workflow using deformable image registration. Key data collected included the size and location of recurrent tumors, target volumes, and their spatial relationship to previously treated volumes.

OARs such as the spinal cord, brachial plexus, lungs, esophagus, and trachea were contoured and evaluated for cumulative dose exposure. Reirradiation treatment plans were developed using institutional planning systems and delivered via LINAC with daily cone-beam CT for image guidance. Prescriptions were formulated to cover at least 95% of the target volume while adhering to recommended OAR constraints per QUANTEC and AAPM guidelines. MRI-guided contour refinement impacted target definition in most cases. In some patients, CT-based planning alone led to over-contouring due to inadvertent inclusion of adjacent, non-target structures.

In other instances, critical tumor extensions were underrepresented. Integration of MRI enabled more accurate delineation, generally resulting in smaller and more anatomically precise target volumes. Reirradiation of recurrent Pancoast tumors is both technically feasible and potentially effective when performed with careful planning and strict adherence to dose constraints. Our findings underscore the considerable variability in contouring approaches, likely stemming from the absence of standardized guidelines for reradiating tumors in this complex anatomical region.

Notably, most target volumes were defined using multimodal imaging, emphasizing the value of incorporating MRI and nuclear medicine techniques to optimize tumor localization and staging. The utility of multimodal imaging in improving target accuracy has been well documented across various tumor sites [8-112]. Advanced radiotherapy techniques-such as adaptive radiotherapy, proton therapy, or stereotactic body radiation therapy (SBRT)-may further facilitate dose escalation while limiting toxicity to previously irradiated tissues. Individualized planning that accounts for prior dose distributions, current anatomy, and disease extent remains essential for ensuring treatment, safety and efficacy.

In summary, reirradiation represents a viable option for selected patients with recurrent Pancoast tumors but necessitates a highly individualized and image-guided approach. Our analysis highlights the critical role of multimodal imaging, particularly MRI, in improving target definition. To enhance consistency and outcomes, future initiatives should focus on establishing contouring atlases and prospective registries dedicated to reirradiation of recurrent thoracic tumors, including Pancoast recurrences.

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