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Original Report

The effect of arm position on the dosimetry of thoracic stereotactic ablative radiation therapy using volumetric modulated arc therapy

David B. Shultz MD, PhD [a,†], Seong Sun Jang MD, PhD [b,†], Alexandra L. Hanlon PhD [a,c], Maximilian Diehn MD, PhD [a,d,e], Billy W. Loo Jr. MD, PhD [a,d,*], Peter G. Maxim PhD [a,d,*]

[a] *Department of Radiation Oncology, Stanford University School of Medicine, Stanford, California*
[b] *Department of Radiation Oncology, College of Medicine, The Catholic University of Korea, Seoul, Korea*
[c] *School of Nursing, University of Pennsylvania, Pennsylvania*
[d] *Stanford Cancer Institute, Stanford University School of Medicine, Stanford, California*
[e] *Institute for Stem Cell Biology and Regenerative Medicine, Stanford University School of Medicine, Stanford, California*

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Abstract

Purpose: Patient comfort and positioning stability may be improved in the arms down (AD) compared with the typical arms up (AU) position in thoracic stereotactic ablative radiation therapy (SABR). We compared plan quality for AD vs AU when using volumetric modulated arc therapy (VMAT), and evaluated the sensitivity of AD plans to arm positioning variability.

Methods and materials: We took plans of 14 patients with 17 lung tumors treated with thoracic SABR using VMAT in the AD position and simulated the same treatments in the AU position by re-optimizing after digitally removing the ipsilateral arm. To evaluate the sensitivity of AD plans to arm positioning variability, all plans were recalculated without re-optimization after assigning water density to the ipsilateral arm (AD-W) and then digitally shifting the arm 2.5 cm anterolaterally (AD-WS).

Results: Between AD and AU plans, statistically significant but clinically insignificant (all original planning constraints met) differences were found for the following parameters: mean planning target volume maximum dose, difference of 2.3% of prescription dose (P = .049); mean intermediate dose conformity index, difference of 0.27 (P = .012); median percent lung volume receiving a minimum of 10, 20, and 30 Gy (V10, V20, and V30), differences of 0.5%, 0.2%, and 0.1%, respectively (P = .040, .007, and .001); and median spinal cord maximum dose, difference of 33.5 cGy (P = .017). Similarly, between AD-W and AD-WS plans, statistically significant but clinically insignificant differences were found for median lung V20 and V30, difference of 0.0% for both (P = .034 and .016, by matched pair analysis).

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* Co-corresponding authors. Department of Radiation Oncology, Stanford Cancer Institute, Stanford University School of Medicine, 875 Blake Wilbur Dr, Stanford, CA 94305.

E-mail addresses: BWLoo@Stanford.edu (B.W. Loo), pmaxim@stanford.edu (P.G. Maxim).

† Co-first authors.

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Conclusions: Our exploratory planning study suggests that when using VMAT for lung tumor SABR, AD and AU positioning achieve clinically equivalent plan quality, and AD plans are insensitive to relatively large variability in arm position.

Introduction

Thoracic stereotactic ablative radiation therapy (SABR), also referred to as stereotactic body radiation therapy (SBRT), is superior to conventionally fractionated radiation therapy for the definitive treatment of early stage non-small cell lung cancer and is an alternative for patients who are not suitable surgical candidates.[1] SABR is also effective for the treatment of metastatic thoracic lesions.[2]

As an emerging treatment modality, several technical aspects of thoracic SABR are currently being evaluated in the clinical setting, including the use of flattening filter free beams in linac-based treatment,[3] optimal strategies for controlling respiratory motion,[4] and the appropriate dose for central versus peripheral tumors.[5,6] Arm position, however, remains an unexplored area of research. While most thoracic SABR patients are treated with their arms up (AU), many are frail and unable to comfortably maintain this position and must instead be treated with their arms down (AD). It is not known how this affects the overall plan quality. It has been assumed that plans with beams entering through the arms are suboptimal and also particularly sensitive to arm repositioning variability. However, it is also possible that treating AD might improve patient stability and comfort, which would decrease movement during setup and treatment, leading to improved dosimetric accuracy, and that adverse dosimetry of beams entering through the arms would be ameliorated by an arc geometry.

Our goal was to conduct an exploratory analysis to determine if arm position had significant dosimetric implications for thoracic SABR. To conduct this research, we took radiation plans for patients who had been treated previously in the AD position, digitally modified their computed tomography (CT) image sets to simulate the AU position, and generated a re-optimized SABR plan. Furthermore, to simulate the impact of AD repositioning variability, we investigated the dosimetric impact of a large arm shift (2.5 cm).

Methods and materials

Patients and treatment

With institutional review board approval, we conducted a retrospective review of patients treated at Stanford University. Patients were selected from a cohort of 257 treated with thoracic SABR between January 2007 and March 2012 using volumetric modulated arc therapy (VMAT). Of these, 14 patients (with 17 tumors in total) were identified and were treated in the AD position. Patients were treated according to previously described methods.[7]

In all 17 plans, a portion of the VMAT beams entered through the ipsilateral arm. Dose and fractionation schedules were 20 Gray (Gy) in 1 fraction (2 tumors), 25 Gy in 1 fraction (8 tumors), 40 Gy in 4 fractions (1 tumor), 50 Gy in 4 fractions (2 tumors), 50 Gy in 5 fractions (2 tumors), and 60 Gy in 5 fractions (1 tumor). Median gross tumor volume was 9.7 mL (range, 0.5-7.7) and median planning target volume (PTV) was 32.4 (range, 6.5-151.5). Ten tumors were in the right upper lobe, 3 tumors were in the right lower lobe, and 4 tumors were in the left upper lobe.

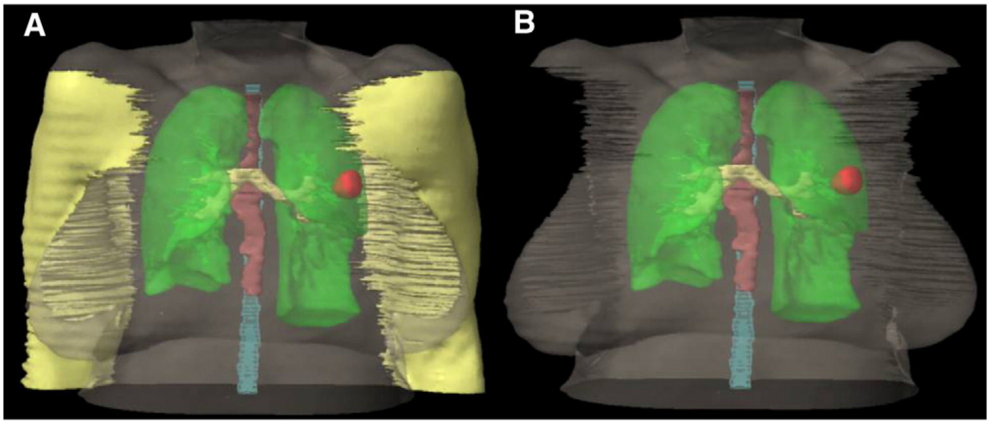

Figure 1 Digital arm subtraction. Three-dimensional rendering of a computed tomography structure set of a patient with a left lung tumor in the arms down position (A) and with the arms digitally subtracted (B). The arms are contoured yellow, the lungs green, the spinal cord cyan, the esophagus brown, the bronchial tree yellow, and the planning target volume red.