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Original Report

Deep inspiration breath-hold technique in left-sided breast cancer radiation therapy: Evaluating cardiac contact distance as a predictor of cardiac exposure for patient selection

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Abstract

Purpose: The purpose of this study was to evaluate the efficacy of voluntary deep inspiration breath-hold (DIBH) over a free-breathing (FB) technique to minimize cardiac radiation exposure in radiation therapy of left-sided breast cancer. Also, to better select patients for DIBH, the correlation between cardiac contact distance (CCD) and cardiac dose was assessed.

Methods and materials: Thirty-five patients with left-sided breast cancer underwent DIBH and FB planning computed tomography scans, and the 2 plans were compared. Dose-volume histograms were analyzed for heart, left anterior descending coronary artery (LAD), left ventricle (LV), and left lung. Axial CCDs and parasagittal CCDs (FB-CCDps) were measured on FB planning computed tomography scans.

Results: Dose to heart, LAD, LV, and left lung was significantly lower in DIBH plans than in FB by all metrics. When DIBH was compared with FB, mean dose (Dmean) for heart was 0.9 versus 2.5 Gy; for LAD, 4.0 versus 14.9 Gy; and for LV, 1.1 versus 3.9 Gy ($P < .0001$), respectively. Seventy-five percent of the patients had a dose reduction of ≥ 0.9 Gy in Dmean to heart, ≥ 3 Gy in Dmean to LAD, and ≥ 1.7 Gy in Dmean to LV. FB-CCDps was associated with an equivalent uniform dose to heart, LAD, and LV for both the DIBH and FB plans ($P \leq .01$); FB axial CCD measures were not.

Conclusions: DIBH is a simple and highly effective technique to reduce cardiac exposure without compromising target coverage. FB-CCDps is potentially a very good predictor for cardiac exposure: the longer the FB-CCDps, the higher the dose. Our findings suggest that at least 75% of

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patients with left-sided breast cancer might benefit from the DIBH technique in terms of potentially clinically relevant dose reduction to cardiac structures, and therefore, it should be instituted as routine clinical practice.

Introduction

Although long-term data confirm the essential role of adjuvant radiation therapy in improving overall survival and local control in patients with breast cancer (BC), there is also an increasing awareness of its potential morbidity and mortality, especially regarding cardiac toxicity.[1-3] Recent studies have demonstrated an increased subsequent rate of ischemic heart disease after radiation therapy for BC.[4] Cardiac exposure is particularly a concern for patients with left-sided BC because of the anatomic proximity of the heart to the radiation therapy target volume, and in the past decade, many efforts have been made to minimize the dose to the heart in these patients. Various techniques have been developed, such as heart blocking, prone positioning, deep inspiration breath-hold (DIBH), and proton treatment.[5-10] In the DIBH technique, the lungs and chest wall expand during inspiration, moving the breast and thus the high-dose area away from the heart.

DIBH has been evaluated in several treatment-planning studies using various constructor integrated respiratory gating devices, which has consistently resulted in significant reduced cardiac doses.[6,7,11,12] However, DIBH has not yet been routinely implemented in most BC treatment centers because of its required increased resources and workload, as well as the lack of consistent criteria for how to select patients who would benefit most from it.[13]

At our institution, voluntary DIBH treatment has been used for radiation therapy of left-sided BC patients since 2007, and routinely since 2010.[14] The first aim of this study was to assess the efficacy of DIBH over the free-breathing (FB) radiation therapy technique by comparing various dose metrics to normal structures. The second aim of the study was to assess whether simple anatomic metrics such as cardiac contact distance (CCD) measured on an FB planning computed tomography (CT) scan could guide the treating physician to select which patients were likely to benefit from the DIBH technique.

Methods and materials

Patient identification and data collection

After approval was obtained from the institutional review board, we conducted a single-institution retrospective dosimetric analysis. Patients were identified using our patient database as meeting the following inclusion criteria: patients with left-sided BC who underwent both DIBH and FB planning CT scans. Thirty-five consecutive patients treated between 2011 and 2012 were included in this analysis. Patient characteristics are presented in Table 1. At our institution, all patients with left-sided BC receive both FB and DIBH planning CT scans, with the exception of patients not clinically suitable for DIBH. The decision to treat with DIBH or not is at the discretion of the physician. All patients included in this analysis except 1 were treated with DIBH.

Planning CT scan using DIBH

CT simulation was performed with the patient in the supine position using a standard breast board for both FB and DIBH. Before the DIBH CT scan, patients were asked to perform successive breath holds of 10 to 15 seconds. Three-dimensional video surface images were obtained with the AlignRT system (Vision RT, Ltd, London, United Kingdom). Surface imaging was used for both initial patient setup and DIBH monitoring during treatment. Our institutional clinical workflow for radiation therapy of left-sided BC using DIBH has been described previously.[14]

Delineation of target and organs at risk

Clinical target volume was contoured by the time of initial treatment on all DIBH and FB CT scans by the treating physician. For the purpose of consistency in this study, heart, left ventricle (LV), left anterior descending coronary artery (LAD), and left lung (LL) were recontoured by a single radiation oncologist on both DIBH and FB scans. All delineations were performed with the XiO treatment planning system (TPS) (version 4.64, Elekta, Stockholm, Sweden).

Clinical target volume was contoured according to the Radiation Therapy Oncology Group (RTOG) guidelines (www.rtog.org). Heart, LV, and LAD were contoured according to the University of Michigan cardiac atlas by Feng et al.[15] The heart contour included the ventricles, atria, auricles, and pericardium and excluded the root of the aorta, the pulmonary artery and veins, and the vena cava. To achieve optimal comparability between FB and DIBH volumes, the LAD was contoured with a standardized 5-mm diameter from its origin at the left aortic sinus down to the cardiac apex in all cases.[13] When the LAD was difficult to visualize, because no contrast was given during the planning CT scan, the anterior interventricular groove was used as a surrogate. The lung volume was generated automatically with the autocontouring tool of the TPS.