The Analysis of Confounding Factors in Volume Reconstruction of 3DCRT with Spiral Mode CT Simulation

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Abstract

This study analyzed the difference in reconstructing volume by using phantom model between various settings of axial-mode and spiral-mode computed tomography (CT) simulator for three-dimensional conformal radiotherapy. Three phantom balls with different diameters (5.1, 9.9, 12.2 cm) were scanned by a single-row detector CT simulator. The volumes of all phantom balls were reconstructed in the same system. The exactly calculated phantom ball volumes were the baselines as compared to the volumes by the conventional axial-mode CT reconstruction. The reconstructed volumes from the axial scanning mode were compared with the corresponding settings of the spiral scanning mode in CT simulation, with four different Hounsfield (HU) thresholds, three different pitches (1, 1.5 and 2), and four different slice widths (1, 2, 3 and 5 mm). The reconstructed volumes were less than the exactly calculated volumes in all phantom balls using the conventional axial-mode CT simulation. Larger slice width and HU threshold were associated with larger difference between the exactly calculated volumes and reconstructed volumes in axial CT mode. For the small phantom ball at slice width of no more than 3 mm, there were less than 5% of volume losses compared with axial-mode CT settings. The lowest HU threshold and slice width of less than 5 mm were needed to maintain volume loss of less than 5% in medium and large balls. As compared to axial-mode scanning, spiral-mode scanning offered volume reconstruction loss of less than 5% at almost all settings. The exceptions existed in the small phantom ball with slice width of 5 mm, spiral pitch of 1.5 and 2 at 50 HU, and slice width of 5 mm, spiral pitch of 2 at 0 HU. Slice interval, spiral scanning pitch and HU threshold were the factors with impact on the accurate estimation of volume reconstruction by spiral CT simulator. Spiral CT mode was feasible in most scanning settings, with acceptable volume reconstruction accuracy threshold of more than 95%.

Keywords: Three-dimensional conformal radiotherapy, Spiral-mode computed tomography, Volume reconstruction, Phantom

1. Introduction

Conventional computed tomography (CT) systems with the X-ray tubes around patients and all images reconstructed in a slice are operated in exactly static table position. In recent years, spiral volumetric CT (also referred as a helical CT) with the single breath hold technique has become the predominant mode of operation. In such a scanning mode, continuous couch transportation and detector rotation are integrated during data acquisition [1-4]. Consequently, the projections collected at different view angles do not represent line integrals of the same object location. When the scanned object position changes constantly from view to view, the property of conserving total attenuation no longer holds.

Spiral CT imaging has been used frequently in the radiology department because of its rapid and superior application in cases requiring high longitudinal resolution. It allows clinicians to obtain virtual representation of the patient for calculating the target volume and dose distribution. However, the position-related volume reconstruction accuracy is not fully evaluated in CT simulation of three-dimensional conformal radiotherapy (3DCRT) [5-7]. This study investigated the difference in the reconstructed volume using 3DCRT planning design between exactly calculated volumes,

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