Title: Volumetric vs. Conventional 4-dimensional CT in Non-Small Cell Lung Cancer Patients

Trainee Name: Heather Young

Supervisor(s): Dr. Stewart Gaede and Dr. Ting-Yim Lee

Structured Abstract:

Introduction: 4-dimensional computed tomography (4D-CT) imaging is part of the standard of care for patients with non-small cell lung cancer who will undergo radiation therapy. Conventional acquisition methods are limited by the narrow axial field-of-view (aFOV) of the scanner (40 mm or less), and irregular breathing motion often leads to visually obvious motion artifacts in the images [1]. These artifacts can obscure structural information in the image, and lead to artifacts in functional images [2]. Volumetric CT (vCT) scanners have a wider aFOV (160 mm), so are able to collect image data over a large volume simultaneously. The objective of this study is to compare phantom and patient images acquired using conventional and volumetric 4D-CT for motion artifacts that may impact radiation treatment planning or functional imaging. We hypothesize that conventional 4D-CT images will have some visible motion artifacts, while no visible artifacts will be present in the volumetric 4D-CT images.

Methods: A Quasar Respiratory Motion Phantom (Modus Medical Devices, London Canada) with a moving insert containing four polystyrene spheres was imaged on a GE Revolution 256-slice vCT scanner, and a clinical 16-slice Philips Brilliance Big Bore CT simulator. 4D-CT images of four patients with non-small cell lung cancer were acquired on the same two scanners before radiation therapy. vCT was acquired using the following parameters; cine mode, 0.28s/revolution, 160mm aFOV, 120 kV, and 10 mA (for 45 s). Clinical 4D-CT simulations were acquired using helical mode, 0.5s/revolution, 24 mm aFOV, 120 kV, 97 mA, and pitch adjusted for respiratory rate. The phantom was imaged under three breathing conditions: 1) sinusoidal, 2) baseline drift, and 3) irregular amplitude.

Results: In the vCT images, phantom motion was strongly correlated to the known motion trace (sinusoidal: r=0.998, p<.0001; baseline drift: r=0.9972, p<.0001; irregular amplitude: r=0.9974, p<.0001). Motion artifacts were clearly visible in the clinical images of both the phantom and lung cancer patients, but no artifacts were present in images from the vCT scanner.

Discussion: In the phantom study, the internal phantom motion was accurately detected in the acquired images. In addition, the volumetric images were all free of visible motion artifacts. These findings have significant implications for both CT simulation for radiation treatment planning (structural imaging) and for functional imaging of the tumour and surrounding healthy tissue. Previous studies have shown that motion artifacts can lead to artifacts in CT ventilation imaging [2], which may be eliminated using volumetric imaging. This may be used in advanced treatment planning techniques in which highly functioning lung tissue is spared radiation dose, potentially decreasing radiation-induced lung toxicity.