PREDICTING MEAN HEART DOSE IN LEFT-SIDED BREAST CANCER PATIENTS

Dominique Mathieu MD MSc, Nicolas Côté MSc, Stéphane Bedwani PhD, Noémie Lahaie TRM, Andrée-Anne Bernard MD, Jean-François Aubry PhD, David Roberge MD, Sophie Lavertu MD, Pierre Rousseau MD, Toni Vu MD

Département de radio-oncologie, Centre hospitalier de l'Université de Montréal (CHUM), 1560 Sherbrooke Est, Montréal, Québec H2L 4M1, Canada

Introduction: Whole breast tangential intensity modulated radiation therapy (IMRT) for left-sided breast cancer patients carries a long-term risk of cardiac toxicity. The probability of major coronary events increases linearly with the mean dose to the heart, with no minimal threshold for risk. The aim of this study is to determine if free breathing (FB) treatment planning images can be used to identify left-sided breast cancer patients who will benefit substantially from deep inspiration breath hold (DIBH) irradiation.

Methods: Thirty two early-stage left-sided breast cancer patients who underwent breast-conserving surgery followed by adjuvant hypofractionated whole breast radiotherapy using tangential IMRT were included. For each patient, planning image acquisition included a FB and a DIBH CT scan. Patients received 42.5 Gy in 16 fractions by DIBH tangential irradiation. In a first step, FB tangential IMRT plans were retrospectively optimized to obtain equivalent DIBH planning target volume (PTV) coverage. Tangential field placement and organ at risk (OARs) delineation were performed by a radiation oncologist as per RTOG 1005. Correlation between mean heart dose and in-field heart volume was obtained
through linear analysis. In a second step, a medical physicist blindly performed tangential field placement on FB images and estimated in-field heart volume from maximum depth of heart penetration assuming a spherical cap equation. Sensitivity and specificity in selecting patients with critical mean heart dose ≥ 3 Gy was performed using estimated in-field heart volume.

**Results:** Means (±SD) for delineated heart volume, in-field heart volume and mean heart dose were respectively 658 ± 97 cc, 25 ± 17 cc and 2.6 ± 1.0 Gy. A correlation between mean heart dose (D) and irradiated heart volume (V) was found through linear regression (D = 0.05 · V + 1.29; R² = 0.84). Means for estimated depth of heart penetration and in-field heart volumes were respectively 1.4 ± 0.5 cm and 28 ± 18 cc. Sensitivity and specificity in identifying patients with mean heart dose ≥ 3 Gy from estimated in-field heart volumes were 90% and 100%.

**Conclusion:** Tangential field placement can be performed on FB treatment planning acquisition images for rapid selection of left-sided breast cancer patients who will most benefit from DIBH irradiation.
Supplemental material: The innovation of this work describes a method to estimate the mean heart dose of a tangential whole breast irradiation patient at the scanning station. With this new practice, patients who have been estimated to have a high mean heart dose may undergo a second planning computed tomography scan in deep inspiration breath hold (DIBH) immediately after their first free breathing scan. This will benefit the clinical workflow, as patients will no longer have to return on a later date for a second DIBH planning scan, further delaying their treatment. The estimation is based on a geometric problem where the irradiated volume is assumed to hold the shape of a spherical cap. The height of the cap can be measured by estimating the tangent plane intersecting the heart and measuring the maximum penetration depth. The diameter of the sphere is the anterior-posterior width of the heart. With the estimated volume, mean heart dose can be predicted using Figure 1.

Figure 1: Mean heart dose against heart volume included in tangential field