# Breath-to-breath displacement of cardiac substructures among patients with mediastinal lymphoma using deep-inspiration breath hold

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## Introduction

- Deep-inspiration breath hold (DIBH) is increasingly being adopted in the management of patients with mediastinal lymphoma in an effort to reduce the radiation dose to organs at risk.
- Unfortunately, there are limited data regarding the reproducibility of the DIBH, which could impact appropriate target coverage or accurate dose reporting to the critical structures.
- Cardiac substructures, in particular, may be sensitive to intrafractional motion due to breathing and cardiac motion as well as their close proximity to the diaphragm.

**The purpose of this study was to investigate breath-to-breath motion of the heart and its substructures among DIBH patients undergoing radiation for mediastinal lymphoma.**

## Patients & Methods

- Following IRB approval, 9 patients with mediastinal lymphoma were identified.
- Patients underwent three 3D CT scans using active breathing control, with IV contrast for the third scan.
- Using MimVista software, the cardiac structures were contoured per the University of Michigan cardiac atlas on the IV contrast scan. The contours were then propagated to the other 2 CT scans and edited accordingly.
- The centroid position of each of the cardiac substructures was exported for basic statistical calculations.
- Data was compared with 4D intrafractional motion reported on a previous study for free-breathing (FB) patients[1].

**Table 1. Mean centroid displacement of the cardiac substructures during DIBH or FB**

| | Centroid X Displacement (cm) | | Centroid Y Displacement (cm) | | Centroid Z Displacement (cm) | |
|---|---|---|---|---|---|---|
| | FB | DIBH | FB | DIBH | FB | DIBH |
| Heart | 0.13 | 0.13 | 0.15 | 0.16 | 0.55 | 0.30 |
| Left Atrium | 0.28 | 0.26 | 0.21 | 0.23 | 0.65 | 0.40 |
| Right Atrium | 0.21 | 0.19 | 0.38 | 0.3 | 0.68 | 0.38 |
| Left Ventricle | 0.25 | 0.31 | 0.25 | 0.26 | 0.70 | 0.36 |
| Right Ventricle | 0.33 | 0.20 | 0.19 | 0.27 | 0.74 | 0.36 |
| Tricuspid Valve | 0.61 | 0.18 | 0.56 | 0.36 | 0.87 | 0.25 |
| Mitral Valve | 0.56 | 0.66 | 0.41 | 0.23 | 0.77 | 0.77 |
| Pulmonic Valve | 0.41 | 0.48 | 0.50 | 0.58 | 0.63 | 0.59 |
| Aortic Valve | 0.43 | 0.55 | 0.42 | 0.30 | 0.95 | 0.65 |
| LAD | 0.46 | 0.56 | 0.77 | 0.69 | 1.13 | 1.07 |
| Circumflex Artery | 0.7 | 0.39 | 0.50 | 0.45 | 1.07 | 0.47 |
| RCA | 0.66 | 0.46 | 0.64 | 0.46 | 1.04 | 0.86 |

**Figure 1. Mean Centroid X Displacement (cm)**

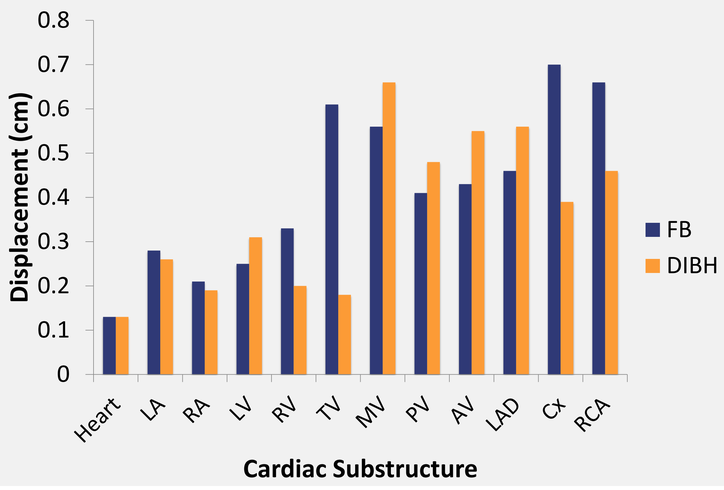



**Figure 2. Mean Centroid Y Displacement (cm)**

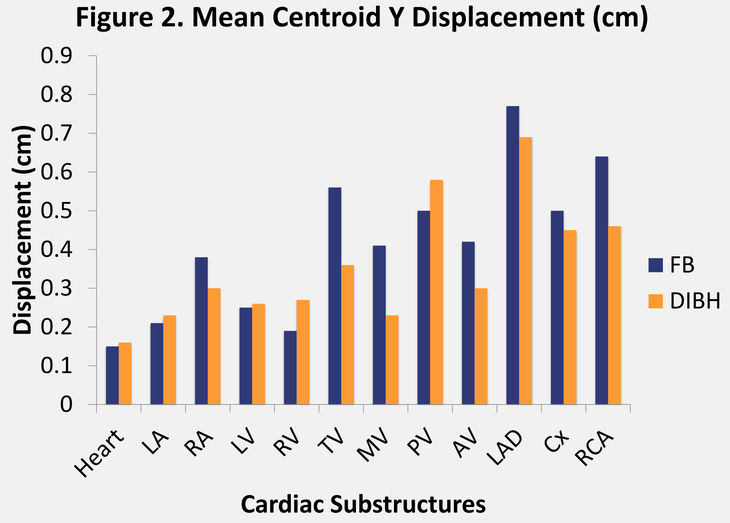
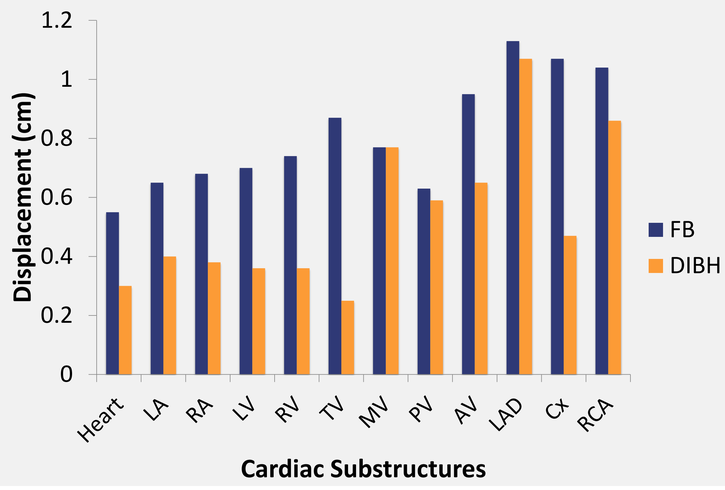



**Figure 3. Mean Centroid Z Displacement (cm)**




## Results

- See **Table 1** and **Figures 1-3**.
- Among the chambers, the maximal displacement ranged between 0.19-0.31 cm in the X and Y directions, which resembled FB. The Z direction ranged between 0.3-0.4, which was lower than with FB (0.65-0.74).
- The valves were displaced 0.18-0.66 in the X and Y directions, which resembled FB. The Z displacement was 0.25-0.77, which was lower than FB (0.63-0.95).
- The vessels were displaced 0.45-0.69 in the X and Y directions, which resembled FB. In the Z direction, the displacement was 0.47-1.07, while it was 0.95-1.13 for FB.

## Conclusion

- Intrafractional motion of the cardiac substructures in the X and Y directions was similar between DIBH and FB; however, Z displacement was typically smaller with DIBH.
- Further investigation on the impact of breath-to-breath reproducibility on target coverage and dose to the organs at risk is needed.

References: 1. Guzhva et al. *Int J Radiat Oncol Biol Phys*. **2017**, 99, 2, S62.

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