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Cardiac Substructure Tracking During Ablative Radiotherapy

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(Authors Hindley, Shieh, Lydiard and Keall have submitted a record of invention for this work)

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INTRODUCTION

- Stereotactic radioablation has shown recent promise in the treatment of cardiac arrhythmias
- We have developed an algorithm which utilizes diaphragm tracking[1] to account for the respiratory component of cardiac substructure motion during ablative radiotherapy
- This algorithm was validated using the left atrium (LA) as a prospective target on a digital phantom

RESULTS

- A stereotactic radioablation procedure was simulated over two 360° gantry rotations with a 5-minute treatment time. Results for the first minute are shown in Figures 2a and 2b
- Mean geometric accuracy was -0.64, 0.56 and -1.90 mm along the LR, SI and AP axes respectively. Target motion was presumed to be negligible along the LR axis and was therefore predicted as static
- Mean dice similarity between predicted and ground truth volumes was 0.84 and > 99 % coverage was achieved using a 3 mm margin

METHOD

Our proposed workflow consists of five steps:

1. Segment the diaphragm, heart and target on the end-exhale 4D-CT
2. Estimate the trajectories of diaphragm and target motion by end-inhale to end-exhale registration
3. Compute the relative contribution of diaphragm to target motion
4. Track the diaphragm on each kV projection
5. Estimate the respiratory component of 3D target motion

Each 4D-CT and kV projection was generated using the XCAT digital phantom[2] with cardiac and respiratory traces acquired from a healthy volunteer[3]

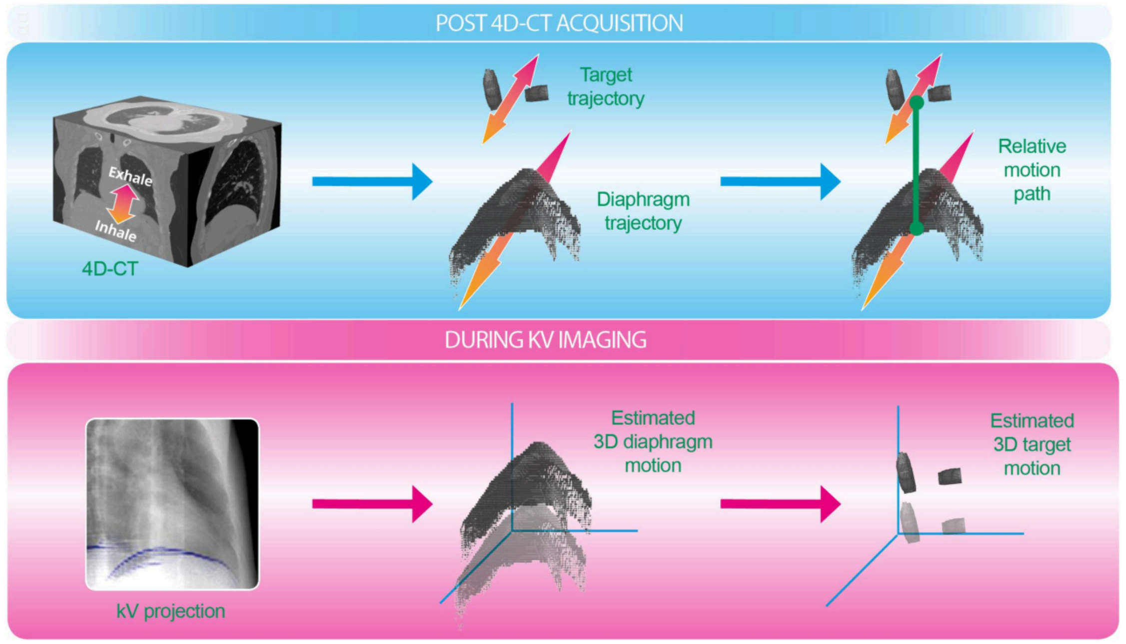

Figure 1. A diagram of our proposed workflow for cardiac substructure tracking

SIMULATION

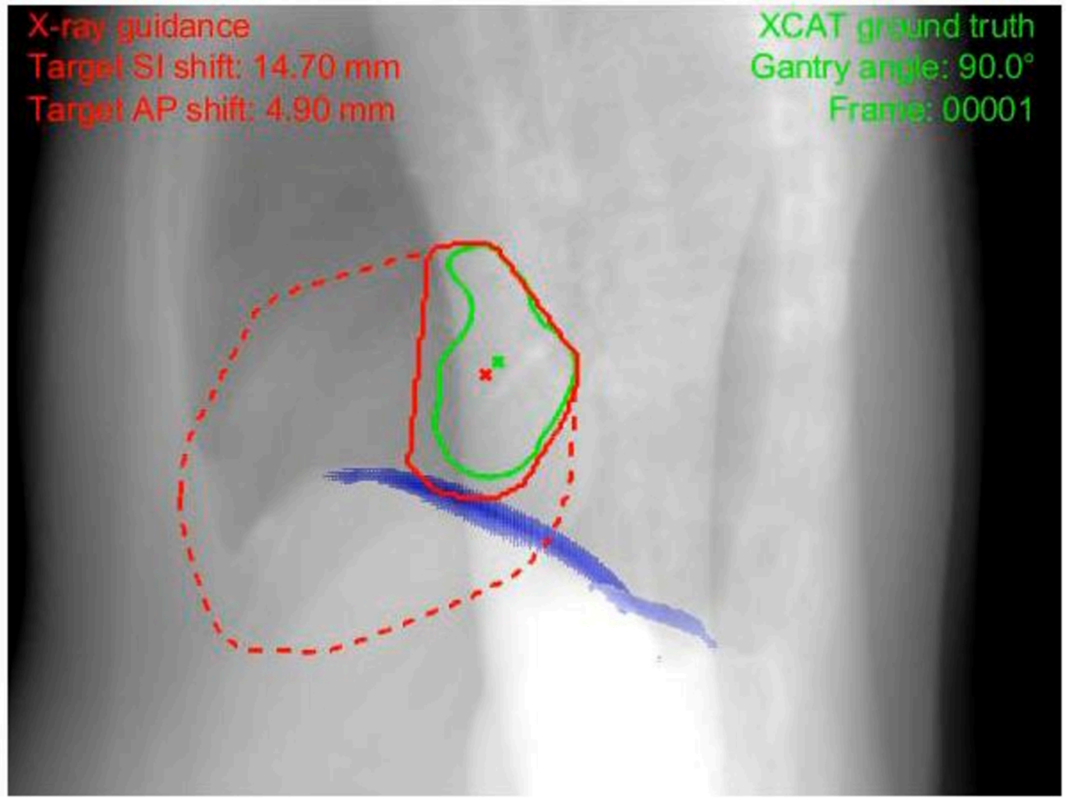

Figure 2a. Simulation with the ground truth position of the LA as well as predicted positions of the LA, heart and diaphragm (in green, solid red, dashed red and blue respectively)

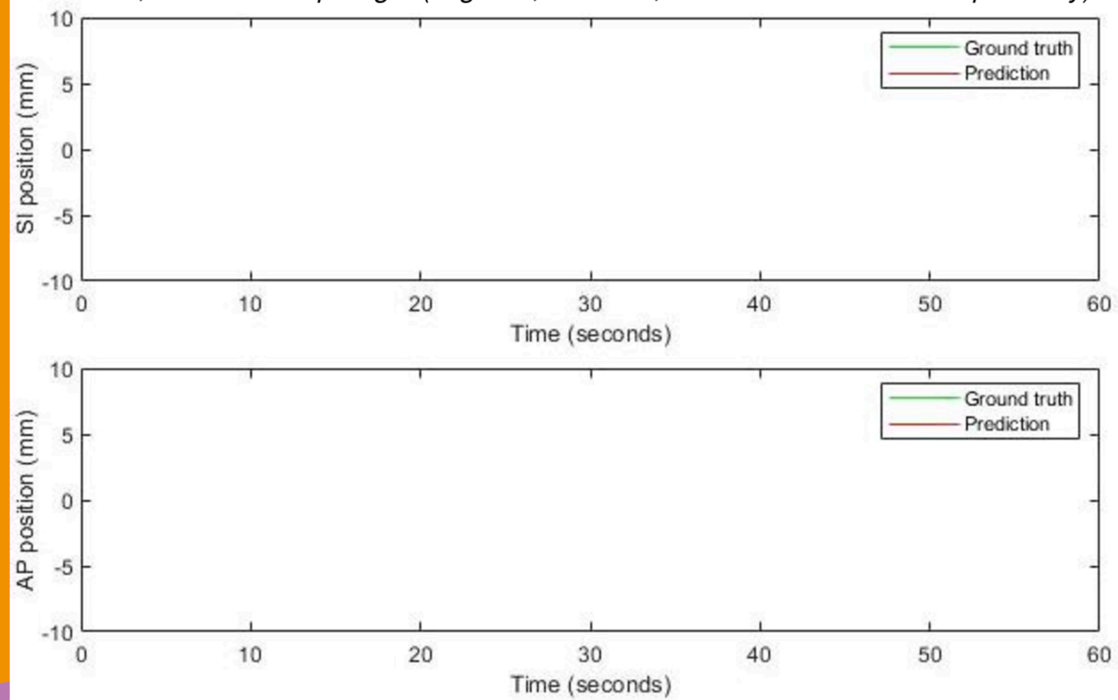

Figure 2b. Tracking performance along the SI and AP axes with ground truth and predicted positions of the LA (in green and red respectively)

CONCLUSION

- **We present a method for non-invasive, markerless tracking of cardiac substructures during ablative radiotherapy**
- By utilizing kV imaging, our method can be implemented on a standard linear accelerator without the need for additional equipment

REFERENCES

1. Hindley, et al. *Medical Physics* (2019) 46(10)
2. Segars, et al. *Medical Physics* (2010) 37(9)
3. García-González, et al. *IFMBE* (2013) 41