Assessing variation in local lung function prior to, during and following radiation therapy

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INTRODUCTION

- Jacobian methods have been used to to create surrogates for local lung function derived from four-dimensional-computed-tomography (4DCT) scans.[1-2]
- Integrity of functional avoidance radiation therapy (RT) plans is dependent on accuracy of surrogate measures
- Mechanical ventilation can be used to precisely control breathing parameters of non-human subjects affecting surrogates, and compare the results to human subjects

AIM

The purpose of this work is to quantify the repeatability of lung tissue elasticity measures for the purpose of creating functional avoidance treatment plans and assessing local response to radiation.

METHOD

71 Human subjects underwent RT

- Standard fractionation or stereotactic body radiation therapy (SBRT)
- 2 consecutive 4DCTs were acquired prior to, and up to 3, 6, and 12 months post-RT
- Audio guidance played
- Patient remains in same position for repeat scans

5 Wisconsin Miniatuare Swine™ [3] subjects underwent RT

- SBRT course (5 fractions of 12 Gy)
- 3 consecutive 4DCTs were acquired prior to each treatment fraction and 3 months post-RT
- Mechanical ventilation with controlled tidal volume and breathing rate
- Subjects under anaesthesia

- Local Expansion Ratio (LER) was calculated using LER_N [2] Jacobian method for both subject groups
- Gamma analysis performed to compare repeatability

RESULTS

- ***Figure 1*** *shows intra-day repeatability for a human subject*
- ***Figure 2*** *shows how swine Jacobian maps vary throughout treatment*
- ***Table 1*** *gives gamma pass rates for human and swine subjects for repeat scans on the same day and between pre- and post-RT scans*
  - *Both subject groups show a significant decrease in similarity from intra-day to pre-/post-RT comparisons* ***(p<.001)***
  - *Swine show improved repeatability compared to human subjects for consecutive scans on the same day* ***(p<.001)***
- ***Table 2*** *gives gamma pass rates for swine subjects between fractions, categorized based on dose given between compared fractions*
  - *Lung receiving > 5 or > 10 Gy between compared fractions was significantly less similar than unirradiated lung* ***(p<.001)***

Subject Group	Time Point	
	Intra-Day	Pre- to Post-RT
Human	70%	56%
Swine	85%	60%

Table 1*: Gamma pass rates for all subjects.**

Inter-Fraction Gamma	Unirradiated Lung	Lung receiving > 5 Gy	Lung receiving > 10 Gy
Swine	74%	65%	54%

Table 2*: Inter-fraction gamma pass rates for swine subjects.**

**Gamma Criterion used: 1.06 Jacobian threshold, 2 mm distance to agreement*

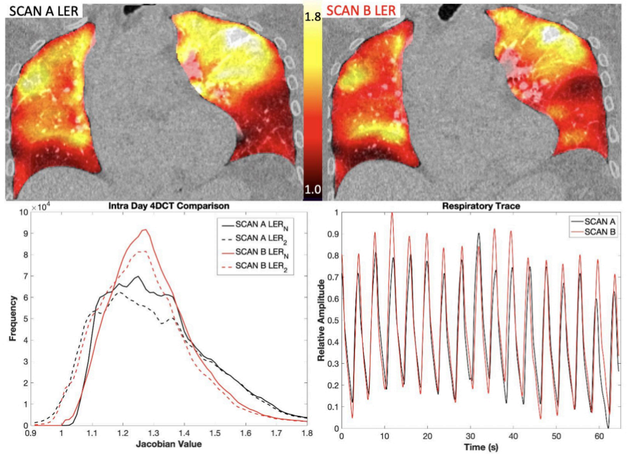

Figure 1*: Human subject repeatability. Scans A and B were acquired 5 minutes apart for a single subject. Their Jacobian maps showing local lung function variation, distribution of Jacobian values and respiratory breathing traces are given.*

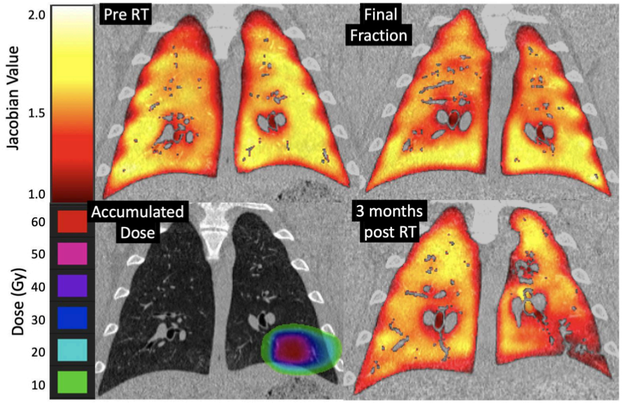

Figure 2*: Swine subject lung function throughout treatment. Jacobian maps are given for a single swine subject for the first and last fraction, and 3 months following radiation therapy.*

CONCLUSIONS

- Swine subjects showed increased repeatability of lung function surrogates compared to human subjects
- Comparing pre- and post-RT scans showed significantly less similarity than consecutive scans acquired on the same day
- Swine subject inter-fraction similarity was highest for unirradiated lung, but still lower than intra-day repeatability
- Controlling breathing parameters and patient motion gives a lower limit for uncertainty in these functional surrogates

ACKNOWLEDGEMENTS

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