Respiratory Motion Management in Stereotactic Ablative Radiotherapy:
A pilot study investigating the efficacy and reproducibility of the CIVCO Body Pro-Lok™ Respiratory Belt

Lloyd Smyth, Yolanda Aarons, Jim Frantzis, Nola Bailey
Introduction

• Role of motion management in Stereotactic Ablative Radiotherapy (SABR)

• Aims & methods of this pilot study

• Results

• Discussion and clinical possibilities

• Future directions
Oligometastases and SABR

- Limited number of well localised metastases

- Can be controlled with SABR → delay disease progression\(^1-4\)
  - Improves quality of life\(^4\)

- Deliver BED > 100Gy

- Additional dose escalation may further improve outcomes\(^4\)
Respiratory Motion Management

- Pulmonary and hepatic lesions are subject to respiratory motion

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<thead>
<tr>
<th>Motion Restrictive</th>
<th>Motion Compensating</th>
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<tbody>
<tr>
<td>Abdominal Compression</td>
<td>Real-Time Tumour Tracking</td>
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<td>• Rigid Plate</td>
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<td>• Drape</td>
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<td>• <strong>Pneumatic Belt</strong></td>
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<td>Breath Hold Techniques</td>
<td>Respiratory Gating</td>
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</table>
CIVCO Respiratory Belt

- Pneumatic
- Evenly disperses pressure across abdominal plane
- Low electron density

Image courtesy of CIVCO Medical Solutions (Orange City, Iowa)
Clinical Context

• Can respiratory compression facilitate SABR dose escalation?

Respiratory Motion Reduced → Smaller Target Volumes → Decreased health tissue irradiation → Dose escalation permitted
Clinical Context

- Can we combine respiratory compression with respiratory gating to increase treatment efficiency?

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Aim

To evaluate:

– The **efficacy** of the respiratory belt in limiting respiratory motion

– The **reproducibility** of using the respiratory belt

– The **comfort** of the respiratory belt

– The impact of **belt pressure** on the above outcomes
Methodology

- Prospective pilot study
- Ten healthy participants
- Low Risk HREC approval
- Varian Real-time Position Management (RPM) system
- Analysis of breathing traces
- Free breathing (FB), Low pressure (LP), High pressure (HP)
Methodology – Set-up

TOX/JOR level

Belt Index

Rail System

RPM Marker Box
Methodology

Healthy Participants (n=10)

RPM Breathing Traces

Free Breathing x3 (Base-line)
Low Pressure x3 (~1kPa)
High Pressure x3 (~5kPa)

Random Order
Methodology - Endpoints

• **Efficacy:**
  – Average maximum displacement of the RPM marker box from origin
  – Amplitude of breathing motion

• **Reproducibility:**
  – Variation in average maximum displacement of the RPM marker box

• **Comfort:**
  – Scored by each participant on a visual analogue scale
Methodology

- Average max. displacement from origin was determined by measuring the magnitude of peaks and troughs.
Methodology

• Average max. displacement from origin was determined by measuring the magnitude of peaks and troughs.
Results

Average Max. Displacement vs Pressure

Free Breathing
Baseline Mean

Free Breathing
Low Pressure (1kPa)
High Pressure (5kPa)

Max. Displacement from Origin (cm)

◊ = Group Mean
## Results

### Efficacy - Difference between group means

<table>
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<tr>
<th>Comparison</th>
<th>△ Mean Max. Displacement</th>
<th>p value</th>
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<tbody>
<tr>
<td>FB vs LP</td>
<td>0.01mm</td>
<td>0.961</td>
</tr>
<tr>
<td>LP vs HP</td>
<td>0.09mm</td>
<td>0.093</td>
</tr>
<tr>
<td>FB vs HP</td>
<td>1mm</td>
<td>0.055</td>
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</tbody>
</table>

p<0.05 for significance

### Reproducibility – Difference in STD of group means

<table>
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<tr>
<th>Belt Pressure</th>
<th>Standard Deviation</th>
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<tbody>
<tr>
<td>Free Breathing</td>
<td>0.11mm</td>
</tr>
<tr>
<td>Low Pressure</td>
<td>0.09mm</td>
</tr>
<tr>
<td>High Pressure</td>
<td>0.05mm</td>
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</tbody>
</table>

p=0.14
Results

Mean Comfort Score LP vs HP

Mean = 1.8
Mean = 6.2

Mean difference = 4.37
P<0.0001
Discussion

• Need to use a higher pressure when using belt

• Comfort/tolerability should be considered

• Require n=60 to confirm statistical significance
Expected Results

- Breathing traces for participant 7

Solid lines indicate mean magnitude of peaks/troughs
Paradoxical Effect

• Breathing traces for participant 5

Solid lines indicate mean magnitude of peaks/troughs
Limitations

• Study size of 10 participants

• Healthy volunteers vs real patients

• Use of RPM cube as a surrogate for respiratory motion

  – Ant-Post motion vs Sup-Inf motion\textsuperscript{5-7}
Future Directions

• 4DCT study

• Analyse internal organ motion and tumour motion

• To what extent does compression reduce internal target motion and subsequent treatment margins?
Conclusion

- CIVCO Respiratory Belt shows promising results
- Reduces extent and variability of respiratory motion
- 4DCT and greater study size needed to confirm the significance of benefits
- Potential use of the belt in the future to facilitate SABR dose escalation and to increase the efficiency of respiratory gating
Acknowledgements

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References


