Pediatric Thoracic Volume Modeling for Early Onset Scoliosis: A Validation Study

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Disclosures

• Kristin England, MD: no disclosures
• Charles Ledonio, MD:
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• David Polly, Jr, MD:
  – Grants/Research: DoD, OREF
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  – Consulting: Nuvasive, Ellipse, Kspine
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• Eric Hoggard, MD:
  – Consulting: Siemens
Background

- Early onset scoliosis (EOS) \(\rightarrow\) ↓ thoracic volume and lung volume
- Virtual thoracic volume modeling from plain radiographs has been used in the adolescent idiopathic scoliosis (AIS) population. This correlates within 3% of thoracic volume from CT scans.
- For AIS patients with poor pulmonary function, the modeled 2 year post-op thoracic volume change is strongly correlated with the two year post-op pulmonary function test.
Virtual modeling of scoliotic deformity

- As coronal deformity (Cobb Angle) *increases*, thoracic volume *decreases*
- Cobb Angle >70°, sagittal deformity does not appear to impact thoracic volume
Purpose

- Objective: to validate the use of the virtual radiograph to actual CT model to accurately predict lung volume in EOS patients.
Methods

- Retrospective case study of children <10 years of age with diagnosis of EOS
- Convenience sample of 3 patients with EOS and CT scans (those with CT-based lung volumes)
- Coronal and sagittal radiographs used to model thoracic volume
Methods

- Blender software (2.67b, open access) to create 3D image
  - ‘computationally deformed’ to match chest X-rays
- MiniMagics (v3, Materialise, Plymouth MI) to calculate the volume of the thoracic cavity
- Voxar 3D software (Toshiba, Edinburgh UK) used by Pediatric Radiologist to determine mediastinal volume
- Compare calculated (virtual) volume to gold standard CT-based volume; calculate percent error

Actual CT lung volume  Virtual model volume
Blender default model  Deformed virtual model
Case 1 – 5 yr 7 months, Cobb 74º

<table>
<thead>
<tr>
<th>Subject 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted (CT) volume</td>
<td>751.9cc</td>
</tr>
<tr>
<td>Modeled (calculated) volume</td>
<td>764.8cc</td>
</tr>
<tr>
<td>Percent (%) error</td>
<td>1.60%</td>
</tr>
</tbody>
</table>
### Case 2 – 4yr 10 months, Cobb 92°

| Subject 2                  |  
|----------------------------|--------------------------------------------------|
| Predicted (CT) volume      | 500.0cc                                          |
| Modeled (calculated) volume| 544.0cc                                          |
| Percent (%) error          | 8.30%                                            |
Case 3 – 2yr 10 months, Cobb 76°

<table>
<thead>
<tr>
<th>Subject 3</th>
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</thead>
<tbody>
<tr>
<td>Predicted (CT) volume</td>
<td>530.0cc</td>
</tr>
<tr>
<td>Modeled (calculated) volume</td>
<td>542.0cc</td>
</tr>
<tr>
<td>Percent (%) error</td>
<td>2.20%</td>
</tr>
</tbody>
</table>
Conclusion

- Within 4.0% accuracy of predicted CT volumes → valid comparator to gold standard
- Effective method to analyze lung volume in EOS patients
- Applicability for patients undergoing long-term monitoring, to prevent unnecessary radiation exposure
Discussion

• Applications/recommendations:
  – EOS lengthening – growing rod
  – Compare interventions – growing rod vs other treatment strategies
Thank you!