Defining Parasol Rib Deformity in Hypotonic Neuromuscular Scoliosis: Is there a difference between VEPTR and Growing Rods?

Kristin Livingston MD, David Zurakowski PhD, Brian Snyder MD PhD

(No disclosures)
How are we doing?
Study Goals

- To define parasol rib deformity radiographically
- To compare the efficacy of VEPTR vs. growing rods in controlling parasol rib deformity
- To determine if these interventions improve pulmonary function
Methods

- Retrospective review
  - Growing Spine Study Group (GSSG)
  - Chest Wall and Spine Deformity (CWSD)

- Inclusion criteria:
  - Dx: hypotonic neuromuscular scoliosis
  - Tx: with Vertical Expandable Prosthetic Titanium Rib (VEPTR) or growing rods (GR)
  - At least 1 year follow up

- Exclusion criteria: inadequate records/imaging
Clinical Data

- Gender
- Age at index surgery
- Diagnosis
- Number of lengthenings
- Complications
- Preoperative and final assisted ventilation rating
  
  Parasol Rib Collapse?  
  OR  
  Not?
- T6 total width
- T6 concave width
- T6 convex width
- Maximum thoracic width
- T12 width
- Pelvic inlet width
- Cobb angle
- Kyphosis
- RVA at apex
Table 1: Measurements taken to determine most accurate radiographic descriptor of parasol rib deformity.

<table>
<thead>
<tr>
<th>Simple Ratios</th>
<th>Complex Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVA</td>
<td>( \frac{T6cv}{T6cc} ) * ( \frac{T6}{T12} )</td>
</tr>
<tr>
<td>T6/T12</td>
<td>( \frac{T6cv}{T6cc} ) * ( \frac{T6}{\text{pelvic}} )</td>
</tr>
<tr>
<td>Max/pelvic</td>
<td></td>
</tr>
<tr>
<td>T12/pelvic</td>
<td></td>
</tr>
<tr>
<td>T6/pelvic</td>
<td>lower = worse deformity, higher = more normal</td>
</tr>
<tr>
<td>T6cv/T6cc</td>
<td></td>
</tr>
</tbody>
</table>

* For each ratio or product, lower = worse deformity, higher = more normal.
Statistical Analysis

- Univariate analysis and multivariate logistic regression (backward selection) were applied to identify the ratio most predictive of parasol rib deformity

- $\frac{T6}{T12}$
- $\frac{T6}{\text{pelvic}}$
- $\frac{T6cv}{T6cc}$
- $(\frac{T6cv}{T6cc}) \times (\frac{T6}{\text{pelvic}})$
- $(\frac{T6cv}{T6cc}) \times (\frac{T6}{T12})$

\[\text{(T6cv/T6cc)} \times (\frac{T6}{T12}) = \text{“Parasol Score”}\]
Statistical Analysis

- ROC analysis of Parasol Score
  - AUC = 0.927 (95% CI 0.855-0.998)
  - 0.927 = extremely accurate mathematical model of describing parasol rib deformity.
- Youden’s J-index ➔ optimal cut-off value
  - Parasol rib deformity ≤ 0.56
- Parasol Score ≤ 0.56 has sensitivity = 73% and specificity = 100%
Parasol Score Calculation:

\[ \frac{T6cv}{T6cc} \times \frac{T6}{T12} \]

Parasol Score = 0.12

Parasol Score = 1.04
Parasol score predicts assisted ventilation rating

- Compared with all other AVRs, full time ventilation patients have significantly lower Parasol Scores.

P = 0.003
P = 0.002
P = 0.030
P = 0.043

Room Air
Supplemental O2
Night Time Vent
Part Time Vent
Full Time Vent
<table>
<thead>
<tr>
<th>Variable</th>
<th>VEPTR (N = 23)</th>
<th>GR (N = 22)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at index, yrs</td>
<td>6.7 ± 2.1</td>
<td>7.7 ± 1.7</td>
<td>0.08</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>12 (52%)</td>
<td>15 (68%)</td>
<td>0.36</td>
</tr>
<tr>
<td>Male</td>
<td>11 (48%)</td>
<td>7 (32%)</td>
<td></td>
</tr>
<tr>
<td>Disease</td>
<td></td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>SMA</td>
<td>11 (48%)</td>
<td>9 (41%)</td>
<td></td>
</tr>
<tr>
<td>Myopathy</td>
<td>5 (22%)</td>
<td>7 (32%)</td>
<td></td>
</tr>
<tr>
<td>Muscular Dystrophy</td>
<td>7 (30%)</td>
<td>6 (27%)</td>
<td></td>
</tr>
<tr>
<td>Follow-up, yrs</td>
<td>3.3 (1.5-8.6)</td>
<td>2.9 (1-10.4)</td>
<td>0.62</td>
</tr>
<tr>
<td># Lengthenings</td>
<td>5 (2-15)</td>
<td>2 (0-13)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Complications</td>
<td>83%</td>
<td>41%</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Plus-minus data are mean ± SD compared by Student t-test. Gender, instrumentation and disease are compared using Fisher’s exact test. Number of lengthenings and follow-up time are median (range) and compared by the nonparametric Mann-Whitney U-test.
Table 3. Radiographic Measurements Stratified by Type of Instrumentation

<table>
<thead>
<tr>
<th>Variable</th>
<th>VEPTR (N = 23)</th>
<th>GR (N = 22)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cobb angle, deg</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>63 ± 22</td>
<td>93 ± 22</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Final follow up</td>
<td>52 ± 21</td>
<td>50 ± 23</td>
<td>0.75</td>
</tr>
<tr>
<td>Change in Cobb</td>
<td>-11 ± 23</td>
<td>-43 ± 21</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Kyphosis, deg</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>53 ± 21</td>
<td>59 ± 32</td>
<td>0.61</td>
</tr>
<tr>
<td>Final follow up</td>
<td>51 ± 23</td>
<td>39 ± 18</td>
<td>0.07</td>
</tr>
<tr>
<td>Change in kyphosis</td>
<td>-2 ± 19</td>
<td>-23 ± 23</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Parasol Score</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>0.57 ± 0.20</td>
<td>0.54 ± 0.21</td>
<td>0.61</td>
</tr>
<tr>
<td>Final follow up</td>
<td>0.50 ± 0.22</td>
<td>0.50 ± 0.26</td>
<td>0.96</td>
</tr>
<tr>
<td>Change in Score</td>
<td>-0.08 ± 0.18</td>
<td>-0.04 ± 0.16</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Paired Samples Testing

VEPTR

Growing Rods

Preop Parasol Score

Final Parasol Score

Preop Parasol Score

Final Parasol Score

p = 0.06

p = 0.27
Conclusion

- Parasol Rib Deformity can now be defined as:
  
  Parasol Score = \((T6_{cv}/T6_{cc})*(T6/T12)\)

- Can be used to follow parasol deformity over time
- Is correlated with Assisted Ventilation Rating
- Parasol deformity did NOT improve over time with either type of implant.
- There was a trend towards worsening parasol deformity in VEPTR patients.
Thank you