Early Surgery for Early Onset Scoliosis

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Disclosures

- **Consultant**
  - Depuy–Synthes
  - Medtronic
  - Halifax Biomedical Inc.

- **Institutional Research Support**
  - Depuy–Synthes
  - Medtronic
Overview

- Early Onset Scoliosis – Early Surgery
  - Etiology of Deformity
  - Spine and Pulmonary Growth
  - The Dilemma – Early vs. Late
  - Recent Trend Towards Late Surgery
    - Casting
    - Diminishing Returns
    - Complications
Etiology of Deformity

- The thorax is the 4th dimension of the spine.
- Depending upon whether the primary problem is the spine or the chest wall, the choice of treatment may differ.
Etiology of Deformity

- Facilitate chest wall growth and potentially improve upon pulmonary development.
Etiology of Deformity

- Efforts to correct/maintain scoliosis may not be successful if rib tethers are not addressed.
Growth

- One of the goals of treatment of EOS is the maintenance of spine growth.

- Spine growth is bimodal and has its first peak from birth to 5 years of age.

- Early growth friendly surgery can capitalize on the first peak of spine height velocity.
Growth

- “Golden" period for thoracic spine and chest growth: Birth to 8 years of age.

- “Growth Modulation” – Justify treatment of thoracic deformities before the age of 5 years in order to preserve pulmonary growth.
Growth

- Rib fusions (Campbell, 2003)
  - Opening wedge thoracostomy
  - Increase the thoracic volume ("parasol effect")
  - Performed prior to the end of bronchial tree development (8 years of age).

- Muscle Function?

- Compliance?
Growth

- What about the endothoracic hump?
- Will derotation with early growth guidance improve thoracic volume and diaphragm muscle function?
Dilemma

- By waiting to intervene, the chest wall deformity may become too severe to reverse;

- However, by intervening too early, growth friendly treatment may cause spontaneous fusion.
Trend Towards Late Surgery

- Casting Resurgence
- Diminishing Returns
- Complications
- “Delay Tactic” / “Window of Opportunity”
Prospective study of 136 children with progressive infantile scoliosis

- 94 patients referred & treated early, scoliosis resolved with casting

- 42 patients referred late, casting could reduce but not reverse the deformity

Mehta, JBJS, 87B, 2005
Casting

Effects on Pulmonary Development?

Courtesy J. d’Astous
Casting

- Effects on Pulmonary Development?
Effects on Pulmonary Development?

“Finally, the effects of casting on pulmonary function were not measured but certainly present an area for future study.”
Casting for Infantile Scoliosis: The Pitfall of Increased Peak Inspiratory Pressure

Arjun A. Dhawale, MD,* Suken A. Shah, MD,* Samantha Reichard,* Laurens Holmes Jr, DrPH, PhD,* Robert Brislin, DO,† Kenneth Rogers, PhD, ATC,* and William G. Mackenzie, MD, FRCSC*
Casting

- Effects on Pulmonary Development?
  - Currently unknown.
Diminishing Returns
Lengthening of Dual Growing Rods and the Law of Diminishing Returns

Wudbhav N. Sankar, MD, David L. Skaggs, MD, Muharrem Yazici, MD, Charles E. Johnston II, MD, Suken A. Shah, MD, Pooya Javidan, MD, Rishi V. Kadakia, BS, Thomas F. Day, MD, and Behrooz A. Akbarnia, MD

- ICEOS 2009 – Best Paper Award
Growing-Rod Graduates: Lessons Learned from Ninety-nine Patients Who Completed Lengthening

John M. Flynn, MD, Lauren A. Tomlinson, BS, Jeff Pawelek, BS, George H. Thompson, MD, Richard McCarthy, MD, Behrooz A. Akbarnia, MD, and the Growing Spine Study Group

- Of 58 operative reports made at final fusion that contained comments on spinal flexibility:
  - 19% - Mobile
  - 19% - Decreased Flexibility
  - 62% - Completely stiff
  - 24% - Osteotomies
  - 8% - Thoracoplasty.
The Effect of Rib–Based Distraction Surgery on Spine Growth

- ICEOS 2012 – Best Paper Award - Nominee
The Effect of Rib–Based Distraction Surgery on Spine Growth

Age 5 vs Adult

<table>
<thead>
<tr>
<th>Section</th>
<th>Centimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1–L5</td>
<td>15</td>
</tr>
<tr>
<td>L6–L10</td>
<td>15</td>
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<tr>
<td>L11–L15</td>
<td>20</td>
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</tbody>
</table>

Adult Range: 25–30

Age 5 Range: 15–20
The Effect of Rib-Based Distraction Surgery on Spine Growth

%Expected T1-S1 / Lengthening

- L1-L5
- L6-L10
- L11-L15
The Effect of Rib-Based Distraction Surgery on Spine Growth

% Expected T1-S1 Growth

Age at Time of Lengthening

-50
0
50
100
150
200

0-5 Years
6-10 Years
11+ Years

Chest Wall
& Spine Deformity
Study Group
Alternative Explanation

- Growth only measured on PA radiograph
Alternative Explanation

- Growth only measured on PA radiograph
  - Kyphosis
    - 40 degrees pre-op
    - 65 degrees at L15
  - T1 moves anterior
  - Relatively lower T1–T12
Alternative Explanation

Where: $s$ is the Arc Length
      $\ell$ is the Chord Length
      $\theta$ is the Kyphosis Angle
GMFCS 5

Nov 2010

Dec 2010

June 2013
Alternative Explanation

Dec 2010

June 2013
Alternative Explanation

Dec 2010

June 2013
Thoracic Height

TK = 40°  TK = 49°  TK = 58°  TK = 65°

Centimeters)

TK = 40°  TK = 49°  TK = 58°  TK = 65°
Thoracic Height vs. Arc Length

Coronal T1–T12 Height
- Might be under-calling “true” spinal height

Arc Length
- Increases in spine length along the arc of kyphosis should still represent increases in 3D thoracic volume.
Complications
Complications of Growing-Rod Treatment for Early-Onset Scoliosis

Analysis of One Hundred and Forty Patients

By Shay Bess, MD, Behrooz A. Akbarnia, MD, George H. Thompson, MD, Paul D. Sponseller, MD, Suken A. Shah, MD, Hazem El Sebaie, FRCS, MD, Oheneba Boachie-Adjei, MD, Lawrence I. Karlin, MD, Sarah Canale, BS, Connie Poe-Kochert, RN, CNP, and David L. Skaggs, MD

- 140 Growing Rod Patients

- 58% Complication Rate

- Rate decreased by 13% per each year of patient age at time of initial implant

- Rate increased by 24% per additional surgical procedure
Complications of Growing-Rod Treatment for Early-Onset Scoliosis

Analysis of One Hundred and Forty Patients

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Complications

- **Classification**
  - Severity Grade I – Not require unplanned surgery
  - Severity Grade II – Requires unplanned surgery(ies)
  - Severity Grade III – Alters planned course

- **65 patients from 5 institutions**
  - Only 9% were Grade III

Smith, Johnston, Skaggs, Flynn, Vitale, ICEOS 2012
HRQOL
(EOSQ–24) – Improvements in multiple domains of health–related quality of life after growth friendly surgery in 68 patients with an average age of 6.2 years (range 0 –11 years).

Nutritional status has also been observed to improve after insertion of growth friendly implants.

- Especially true for those children who had failed to thrive (<5th percentile body weight).
HRQOL

- 69 patients treated with casting from CSSG and GSSG – EOSQ–24

- “HRQOL decreases and burden of care increases after undergoing casting.”

- This may just be a short term effect.

- More study is needed.

Matsumoto, ICEOS 2013
Summary

- Casting as a “delay tactic”
  - Pulmonary effects of casting
    - Not known
  - Diminishing Returns
    - May not hold true for Rib–based systems
    - Alternative explanation – sagittal plane

- Complications
  - 58% complication rate vs. 9% SV III
Summary

- Early surgery
  - Maintain spine growth
    - Bimodal. 0–5 years of age
  - Golden period
    - Pulmonary development 0–8 years of age
  - Growth modulation
    - May justify surgical treatment 0–5 years of age
Thank You

IWK Health Centre
Thoracic Height

TK = 40°
TK = 49°
TK = 58°
TK = 65°

Centimeters

Initial  L1–L5  L6–L10  L11–L15

T1–T12 Height
Arc Length (H)
Arc Length (C)
Thoracic Height vs. Arc Length

Coronal T1–T12 Height
- Initial = 12.4 cm
- L15 = 16.5 cm
- Delta = 4.1 cm
- Percent = 33%

Arc Length (C)
- Initial = 12.7 cm
- L15 = 17.4 cm
- Delta = 4.7 cm
- Percent = 37%
Thoracic Height vs. Arc Length

**Coronal T1–T12 Height**
- Initial $= 12.4$ cm
- L15 $= 16.5$ cm
- Delta $= 4.1$ cm
- Percent $= 33\%$

**Arc Length (H)**
- Initial $= 13.5$ cm
- L15 $= 20.6$ cm
- Delta $= 7.1$ cm
- Percent $= 53\%$
The Shilla Growth Guidance Technique for Early-Onset Spinal Deformities at 2-Year Follow-Up: A Preliminary Report

Richard E. McCarthy, MD,* Scott Luhmann, MD,† Lawrence Lenke, MD,† and Frances L. McCullough, RNP, MNSce‡

› 10 patients with a mean age of 7+6 years

› 2-Year Follow-up

› Pre-op 70 degrees was corrected to 27 deg.

› Space available for lung improved 13%.

› Truncal height (C7 to S1) increased 12%.
These patients would have had 49 scheduled lengthening procedures after their initial correction if treated by conventional distraction growing rod methods.
Summary

<8 yo

Spine

Casting

Healthy

Syndromic

Rib

Rib Based Distraction

Spine vs Rib Distraction

Guided Growth
Serial Casting as a Delay Tactic in the Treatment of Moderate-to-Severe Early-onset Scoliosis

Nicholas D. Fletcher, MD,* Anna McClung, BSN, RN,† Karl E. Rathjen, MD,†
Jaime R. Denning, MD,‡ Richard Browne, PhD,‡ and Charles E. Johnston III, MD‡

- Retrospective review of 29 patients
  - 12 Idiopathic
  - 17 Non-Idiopathic

- Average age first cast = 4.4 years

- 3 Casts over 1.4 years
Serial Casting as a Delay Tactic in the Treatment of Moderate-to-Severe Early-onset Scoliosis

Nicholas D. Fletcher, MD,* Anna McClung, BSN, RN,† Karl E. Rathjen, MD,† Jaime R. Denning, MD,‡ Richard Browne, PhD,‡ and Charles E. Johnston III, MD†

- Cobb Angle
  - Initial 69°
  - In Cast 39°
  - Post Cast 61°
  - Final (5.5 yr) 76°

- T1–T12 1.1 cm
Serial Casting as a Delay Tactic in the Treatment of Moderate-to-Severe Early-onset Scoliosis

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Although a cure cannot be expected, an average of 39 months of delay was achieved in this patient cohort and 72.4% have avoided growing spine surgery.
Alternative Explanation

- Implant Design – Radius of curvature
  - T1 moves anterior
  - Relatively lower T1-S1
Our findings suggest that EOS patients with abnormal psychosocial scores were younger at the time of their initial scoliosis surgery.

The number of repetitive surgeries also correlated positively with 3 behavioral problem scores.

...there is a clear need for further investigation of this issue by prospective, multicenter efforts.
The Effect of Rib-Based Distraction Surgery on Spine Growth

- Normalized to age, change in T1–S1/Lengthening
  - L1–L5 159% Expected Growth
  - L5–L10 46% Expected Growth
  - L11–L15 47% Expected Growth
Growth

- Makes sense to preserve growth and allow for pulmonary development.