Perioperative Considerations in AIS: Classification and Imaging

Ronald A. Lehman, Jr., M.D.
Chief, Pediatric and Adult Spine Surgery
Associate Professor of Surgery
Assistant Professor of Neurology
Walter Reed Army Medical Center
Washington, D.C., USA

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KING, MOE, et al. (JBJS 1983)

5 TYPES:

I. L>T (both cross midline)
II. T>L (both cross midline)
III. Thoracic only
IV. Thoracic only (L4 tilted into curve)
V. Double Thoracic (+T1 Tilt)
• First classification that was treatment-based
• Based on extensive Harrington Instrumentation experience
• Promoted “Selective Fusions” of Type II curves when appropriate
• Recognized Double Thoracic curve pattern when appropriate (V)
• Gold Standard for 20 years!
PROBLEMS

• Fair-to-poor inter & intraobserver reliability by 2 separate studies

• Uniplanar - coronal plane-only assessment

• Often tough distinction between Type II & III curves (does the lumbar curve cross the midline?)

• Double and Triple Major curves and isolated Thoracolumbar/Lumbar curves excluded

• Based on Harrington Instrumentation principles
**AIS**

A NEW CLASSIFICATION TO GUIDE EXTENT OF SPINAL ARTHRODESIS

**SIX GOALS**

1. **Comprehensive** - all curve types
2. **2-Dimensional** - increased emphasis on sagittal plane
3. **Treatment-based**
4. **Reliable** - inter and intraobserver
5. **Specific objective criteria** to separate curve types
6. **Practical** and easily understood/usable to scoliosis surgeons

DEFINITIONS
(SRS)

MAJOR CURVE = LARGEST COBB
Always Included in Fusion

MINOR CURVE = ALL OTHERS

??? Include in Fusion
# Minor Curve Structural Criteria

<table>
<thead>
<tr>
<th></th>
<th>Coronal S.B.</th>
<th>Sagittal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PT</strong></td>
<td>$\geq 25^\circ$</td>
<td>$\geq +20^\circ$ (T2-T5)</td>
</tr>
<tr>
<td><strong>MT</strong></td>
<td>$\geq 25^\circ$</td>
<td>$\geq +20^\circ$ (T10-L2)</td>
</tr>
<tr>
<td><strong>TL/L</strong></td>
<td>$\geq 25^\circ$</td>
<td>$\geq +20^\circ$ (T10-L2)</td>
</tr>
<tr>
<td>CURVE TYPE</td>
<td>PT</td>
<td>MT</td>
</tr>
<tr>
<td>------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>1</td>
<td>NS</td>
<td>S*</td>
</tr>
<tr>
<td>2</td>
<td>S</td>
<td>S*</td>
</tr>
<tr>
<td>3</td>
<td>NS</td>
<td>S*</td>
</tr>
<tr>
<td>4</td>
<td>S</td>
<td>S*</td>
</tr>
<tr>
<td>5</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>6</td>
<td>NS</td>
<td>S</td>
</tr>
</tbody>
</table>

*S = Structural  
NS = Non-Structural  
*Major (largest curve)
LUMBAR SPINE MODIFIER

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# Sagittal Thoracic Modifier

(-, N, or +)

<table>
<thead>
<tr>
<th>COBB</th>
<th>Modifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt;+10^\circ)</td>
<td>-</td>
</tr>
<tr>
<td>(+10 - +40^\circ)</td>
<td>N</td>
</tr>
<tr>
<td>(&gt;+40^\circ)</td>
<td>+</td>
</tr>
</tbody>
</table>
NEW CLASSIFICATION SYSTEM OF AIS

3 COMPONENTS

- Curve Type (1-6)
- Lumbar Spine Modifier (A, B, or C)
- Sagittal Thoracic Modifier (-, N, or +)

= Curve Classification (e.g. 1B+)
## RELIABILITY TESTING

<table>
<thead>
<tr>
<th></th>
<th>INTEROBSERVER</th>
<th>INTRAOBSERVER</th>
</tr>
</thead>
<tbody>
<tr>
<td>King</td>
<td>0.49</td>
<td>0.62</td>
</tr>
<tr>
<td>New (Developers)</td>
<td>0.92</td>
<td>0.83</td>
</tr>
<tr>
<td>New (Independent)</td>
<td>0.74</td>
<td>0.89</td>
</tr>
</tbody>
</table>

- **0.75 = GOOD/EXCELLENT**
- **Same 27 Cases of AIS Utilized for Trials**
AIS ALGORITHM

X-RAYS

CLASSIFICATION

TREATMENT

OUTCOME
The Reliability of Preoperative Supine Radiographs to Predict the Amount of Curve Flexibility in Adolescent Idiopathic Scoliosis

Gene Cheh MD
Lawrence G. Lenke, MD
Ronald A. Lehman, Jr., MD
Yongjung J. Kim, MD
Keith H. Bridwell, MD
Ryan Nunley, MD
Kate Keeler, MD

Washington University School of Medicine, St. Louis, MO

Scoliosis Research Society Traveling Fellowship 2011
CURVE CLASSIFICATION 1BN

LEFT SIDE BENDING

RIGHT SIDE BENDING
INTRODUCTION

- Side bending Radiograph is highly subjective with much variability possible within centers & from 1 center to the next
- Preop supine coronal long-cassette x-ray is not effort nor technician-dependent
  - More reliable and reproducible
  - Should be the same each time at all centers!
  - Cobb measurement changes in each spinal region should reflect the inherent “stiffness” of those regions
PURPOSE

Determine the reliability of using Supine long-cassette radiographs as a substitute for side bending films to predict curve flexibility and fusion regions in operative AIS
METHODS

• 689 AIS patients had preop standing AP/Lat, right & left side bending, & supine films

• All curves classified using Lenke Classification

• Patients grouped by location of Major curve
  – Group I - MT (Types 1-4)
  – Group II - TL/L (Types 5 & 6)

• Excluded patients with TL kyphosis >20°
<table>
<thead>
<tr>
<th>Radiographs</th>
<th>Proximal Thoracic (n=282)</th>
<th>Main Thoracic (n=524)</th>
<th>Thoracolumbar/Lumbar (n=496)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing PA</td>
<td>35±9.7º</td>
<td>58±16.3º</td>
<td>47±14.4º</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Supine AP</td>
<td>31±9.9º</td>
<td>46±15.7º</td>
<td>34±13.1</td>
<td></td>
</tr>
<tr>
<td>Side Bending AP</td>
<td>24±10.6º</td>
<td>33±17.3º</td>
<td>19±14.4º</td>
<td></td>
</tr>
<tr>
<td>Supine Flexibility</td>
<td>13±13.5%</td>
<td>21±11.1%</td>
<td>28±15.7%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Side Bending Flexibility</td>
<td>34±18.9%</td>
<td>46±18.9%</td>
<td>64±22.9%</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
## Group I. Lenke Curve Types 1-4

<table>
<thead>
<tr>
<th>Supine Predictor</th>
<th>Side Bend</th>
<th>Standing</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT</td>
<td>r=0.834, p&lt;0.0001</td>
<td>r=0.862, p&lt;0.0001</td>
<td>PT SB = (-5.46) + 0.93 ((PT \text{ SUP}) (r=0.73, p&lt;0.0001))</td>
</tr>
<tr>
<td>MT</td>
<td>r=0.894, p&lt;0.0001</td>
<td>r=0.896, p&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>TL/L</td>
<td>r=0.800, p&lt;0.0001</td>
<td>r=0.877, p&lt;0.0001</td>
<td>TL/L SB = (-11.11) + 0.84 ((\text{TL/L SUP}) (r=0.67, p&lt;0.0001))</td>
</tr>
</tbody>
</table>
### Group II. Lenke Curve Types 5-6

<table>
<thead>
<tr>
<th>Supine Predictor</th>
<th>Side Bend</th>
<th>Standing</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PT</strong></td>
<td>$r=0.785$, $p&lt;0.0001$</td>
<td>$r=0.862$, $p&lt;0.0001$</td>
<td>$\text{PT SB} = (-3.578) + 0.79 \text{ (PT SUP)}$ (r=0.62, $p&lt;0.0001$)</td>
</tr>
<tr>
<td><strong>MT</strong></td>
<td>$r=0.876$, $p&lt;0.0001$</td>
<td>$r=0.859$, $p&lt;0.0001$</td>
<td>$\text{MT SB} = (14.10) + 0.93 \text{ (MT SUP)} + 0.25 \text{ (PT SUP)}$, (r=0.79, $p&lt;0.0001$)</td>
</tr>
<tr>
<td><strong>TL/L</strong></td>
<td>$r=0.681$, $p&lt;0.0001$</td>
<td>$r=0.841$, $p&lt;0.0001$</td>
<td></td>
</tr>
</tbody>
</table>
**PREDICT STRUCTURALITY?**

- Used $\geq 40^\circ$ for TL/L Curves & $\geq 30^\circ$ for PT & MT Curves as threshold of structurality in preop supine radiograph
- Compared to side bending current standard of $\geq 25^\circ$
- Was minor curve(s) considered structural in actual surgery and included in the fusion of major curve?
## CURVE “STRUCTURATLITY” PREDICTION

<table>
<thead>
<tr>
<th>Curve Location</th>
<th>Structural Criteria</th>
<th>Positive Predictive Value</th>
<th>Negative Predictive Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal Thoracic</td>
<td>Supine 30°</td>
<td>0.458</td>
<td>0.922</td>
</tr>
<tr>
<td></td>
<td>SB 25°</td>
<td>0.504</td>
<td>0.923</td>
</tr>
<tr>
<td>Main Thoracic</td>
<td>Supine 30°</td>
<td>0.548</td>
<td>0.911</td>
</tr>
<tr>
<td></td>
<td>SB 25°</td>
<td>0.558</td>
<td>0.894</td>
</tr>
<tr>
<td>Thoracolumbar/Lumbar</td>
<td>Supine 40°</td>
<td>0.685</td>
<td>0.946</td>
</tr>
<tr>
<td></td>
<td>SB 25°</td>
<td>0.758</td>
<td>0.739</td>
</tr>
</tbody>
</table>
CURVE CLASSIFICATION 1CN

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CONCLUSIONS

- A single preoperative SUPINE x-ray is:
  - Non-effort/Technician dependent
  - Reliable in and between centers
  - Highly predictive of side bending x-rays in the PT, MT, & TL/L regions
  - Adjunct to predicting
    - Curve flexibility
    - Curve type
    - Structural vs. Non-structural - minor curves
    - Replacement for Side Benders?????
Accuracy/Benefit of Intraoperative Scoliosis Radiograph to Determine Ultimate Correction and Balance on the Postoperative Standing Film. Should it be Mandatory?

Ronald A. Lehman, Jr., MD*
Lawrence G. Lenke, MD#
Melvin D. Helgeson, MD*
Tobin T. Eckel, MD*
Kathryn A. Keeler, MD#

*Walter Reed Army Medical Center, Washington, D.C.
#Washington University School of Medicine, St. Louis, MO
Introduction

• Thoracic Pedicle Screws
  – More expensive
  – Sig. better major and minor curve correction
  – No neurologic problems and improved PFTs
  – Enables shorter fusion length than hooks


• Imaging- essential to eval correction & implant placement

• CTs - accurate to identifying malpositioned implants
  • Limitations: 1) cost 2) radiation exposure 3) lack of IO avail.
  • Supine position masks true deformity
  • Cobb angle spontaneously corrects ~30% when supine

  Yazici et al., *J Pediatr Orthop* 2001
Purpose

To determine if there was radiographic correlation between long-cassette, intraoperative scoliosis films and the postoperative standing radiographs during the treatment of AIS with pedicle screw instrumentation.
Methods and Materials

• Forty-four (44) consecutive AIS pts. PSF w/ TPS
• Radiographic measurements (curve magnitudes, coronal and sagittal balance, disc angles, etc.)
  – preoperative (PreO)
  – intraoperative (IO)
  – postoperative (PO)
• Intraoperative (IO), prone scoliosis film was obtained after instrumentation and correction
• Compared to the PO, standing film.
Results
Results

- Curve magnitude (MTC)
  - PreO: 57.5° ± 11.9SD
  - IO: 19.34° ± 8.62SD
  - PO: 17.45° ± 9.02SD

- Average age: -15.1±2.21SD years

- Significant correlation (p<0.005) in curve magnitude on IO and PO films for:
  - proximal (PTC) – r = 0.748
  - main (MTC) – r = 0.847
  - TL/L curves – r = 0.775

- 77.3% showed diff. of ≤ 5° from IO to PO
Results

- LIV-H and LIV-α correlation from IO to PO
  - (r=0.497, p=0.001 and r=0.43, p=0.004, respectively).
- 84.1% of cases had correlation less than 5°
- LIV to CSVL & apex of the lumbar curve to the CSVL significantly correlated
  - (r=0.57, p<0.0005 and r=0.50, p=0.001, p=0.001).
Case Example

Preop PA  Intraop PA  Revision IO PA  Immediate PO

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Conclusions

• The intraoperative, long-cassette scoliosis film significantly correlated with the immediate postoperative, standing films for virtually all curve correction and balance parameters.

• Use of intraoperative films provide a valuable tool to guide intraoperative decision-making.

• Intraoperative scoliosis films foreshadow the ultimate correction and balance obtained on the immediate postoperative film.
Thank You!