Development of a Risk Severity Score (RSS) Predicting Surgical Site Infection in Early Onset Scoliosis: Identifying High-Risk Patients

Hiroko Matsumoto, Megan Campbell, Anas Minkara, David Roye, Charlie Johnston, Sumeet Garg, Amer Samdani, John Smith, Paul Sponseller, Peter Sturm, Michael Vitale, GSSG, CSSG
Introduction

Pediatric Surgical Site Infections (SSI) lead to patient, caregiver and healthcare burden:

• Lengthy hospital admissions
• Return to the OR
• Hospital charges for delayed SSI: $154,537 - $961,722
• Healthcare-related infections cost $4.5 billion annually

An abundance of literature exists on risk factors of SSI, but surgeons are unable to provide individual preoperative counseling regarding SSI risk.
This study aims to develop a **Risk Severity Score (RSS)** to predict Surgical Site Infection (SSI) in patients with Early Onset Scoliosis.
Methods

Retrospective cohort study
• 50 institutions from national CSSG and GSSG registries

Inclusion Criteria
• Early Onset Scoliosis diagnosis
• Age 0-21 years on date of surgery
• Growing spinal instrumentation, revision, and fusion (Oct 2010- Dec 2016)

SSI Case Definition:
• 2014 CDC Guidelines: superficial or deep infection (within 90 days of surgery)
# Patient Characteristics

<table>
<thead>
<tr>
<th>Patient Summary</th>
<th>N=1189</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>7.7 ± 3.3</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>512 (43%)</td>
</tr>
<tr>
<td>Female</td>
<td>677 (57%)</td>
</tr>
<tr>
<td>Etiology</td>
<td></td>
</tr>
<tr>
<td>Neuromuscular</td>
<td>403 (34%)</td>
</tr>
<tr>
<td>Syndromic</td>
<td>255 (22%)</td>
</tr>
<tr>
<td>Congenital</td>
<td>242 (20%)</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>289 (24%)</td>
</tr>
<tr>
<td>Preop Major Coronal Curve (degrees)</td>
<td>70.1 ± 23.3</td>
</tr>
<tr>
<td>Procedure</td>
<td></td>
</tr>
<tr>
<td>Growth Friendly Implant</td>
<td>933 (79%)</td>
</tr>
<tr>
<td>Revision</td>
<td>13 (1.1%)</td>
</tr>
<tr>
<td>Fusion</td>
<td>243 (20%)</td>
</tr>
<tr>
<td>Follow up (years)</td>
<td>3.1 ± 1.7</td>
</tr>
</tbody>
</table>
30 risk factors were investigated

- Age
- Gender
- Height
- Weight
- BMI
- Scoliosis etiology
  - Congenital
  - Syndromic
  - Idiopathic
  - Neuromuscular (SB, CP, SMA)
- Presence of fused ribs
- Presence of comorbidities
  - Cardiac
  - Developmental Delay
  - Endocrine
  - Gastrointestinal
  - Immunologic
- Musculoskeletal
- Neurologic
- Nutrition
- Pulmonary
- Urinary incontinence
- Use of assistive devices
  - VP shunt
  - G-tube
  - Assistive ventilation
- Ambulatory status
- Surgery type
  - Index surgery
  - Fusion
  - Revision
- Cobb angle
- Kyphosis
A Multiple Logistic Regression Model was utilized to develop the EOS Risk Severity Score Model.

80 patients had SSI (6.7%)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta</th>
<th>95% CI for Beta</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuromuscular Etiology</td>
<td>0.828</td>
<td>0.148 - 1.508</td>
<td>2.289</td>
</tr>
<tr>
<td>*Spina Bifida</td>
<td>0.376</td>
<td>-0.727 - 1.479</td>
<td>1.456</td>
</tr>
<tr>
<td>*Spinal Muscular Atrophy</td>
<td>0.304</td>
<td>-0.778 - 1.386</td>
<td>1.355</td>
</tr>
<tr>
<td>Urinary Incontinence</td>
<td>0.287</td>
<td>-0.354 - 0.928</td>
<td>1.332</td>
</tr>
<tr>
<td>VP Shunt</td>
<td>0.387</td>
<td>-0.240 - 1.014</td>
<td>1.473</td>
</tr>
<tr>
<td>Developmental Delay</td>
<td>0.347</td>
<td>-0.198 - 0.892</td>
<td>1.415</td>
</tr>
<tr>
<td>Endocrine Comorbidity</td>
<td>1.499</td>
<td>0.881 - 2.017</td>
<td>4.259</td>
</tr>
<tr>
<td>Gastrointestinal Comorbidity</td>
<td>0.276</td>
<td>-0.273 - 0.825</td>
<td>1.318</td>
</tr>
<tr>
<td>Pulmonary Comorbidity</td>
<td>0.19</td>
<td>-0.398 - 0.778</td>
<td>1.209</td>
</tr>
</tbody>
</table>

*SMA or SB presence necessitates Neuromuscular etiology presence
Receiver Operating Characteristic (ROC) curve demonstrates **good discrimination** of those with and without SSI.

Predictive ability (c-statistic) = 70.6%
Model has **excellent calibration** consistent with observed values.

Hosmer-Lemeshow statistics: $p=0.149$
The model equation generates a probability of SSI (RSS)

\[
\text{Probability of SSI} = \frac{\exp [-3.365 + 0.828(\text{Neuromuscular etiology}) + 0.376(\text{Spina Bifida}) + 0.304 (\text{SMA}) + 0.287 (\text{Urinary Incontinence})+ 0.387(\text{VP Shunt}) + 0.347(\text{Developmental Delay}) + 1.449 (\text{Endocrine Comorbidity}) + 0.276(\text{GI Comorbidity})+ 0.19(\text{Pulmonary Comorbidity})]}{1 + \exp [-3.365 + 0.828(\text{Neuromuscular etiology}) + 0.376(\text{Spina Bifida}) + 0.304 (\text{SMA}) + 0.287 (\text{Urinary Incontinence})+ 0.387(\text{VP Shunt}) + 0.347(\text{Developmental Delay}) + 1.449 (\text{Endocrine Comorbidity}) + 0.276(\text{GI Comorbidity})+ 0.19(\text{Pulmonary Comorbidity})]}
\]

- A patient with 0 risk factors: \textbf{3.3% probability of SSI}
- A patient with \textbf{SMA, urinary incontinence, and GI comorbidity}: \textbf{15.8% probability of SSI}
Online User-Friendly RSS Calculator

- The **RSS calculator** is now live:
  - It is based on **preoperative patient characteristics**
  - Generates SSI risk percentage

- RSSs for Idiopathic, Non-Idiopathic and CP are also available
Conclusions

- RSS provides a means of predicting SSI risk in the EOS population using known preoperative patient characteristics

  - It will improve:
    - shared decision making with patients and families
    - Preoperative optimization and perioperative management

- RSS also provides an objective metric for fair comparison of quality outcomes based on variable patient complexity
Next Step

- **Add modifiers to the RSS**
  - Surgical characteristics
  - Antibiotic prophylaxis regimens
  - Hospital characteristics
  - “Subjective” surgeon adjustment

- **Validity studies**
  - Apply RSS to new sets of patient cohort
  - Compare predictive ability with other models (e.g. NSQIP)
Compared to surgeon prediction, RSS score could better differentiate between patients with and without SSI.

16.59% (RSS) vs. 11.63% (Surgeons (Avg.))

13.85% (RSS) vs. 11.44% (Surgeons (Avg.))

Preliminary Analysis
More to come.....
Thank You

EOS RSS:

CP RSS:

Non-Idiopathic RSS:

Idiopathic RSS: