Development of a Risk Severity Score (RSS): What they Tell Us and How We Use Them

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Disclosures

- **Royalties**: Zimmer-Biomet
- **Consultant**: Stryker, Zimmer-Biomet
- **Research Support**: PSSG, SRS, POSNA; OREF
- **BOD**: POSNA, PSSG; SP3
Disclosures

• Hiroko Matsumoto (PhD)
Adelina
9 yo with Congenital Myotonic Dystrophy

Debilitating Head Tilt /Progression of Pelvic Obliquity s/p VEPTR
AR: 9 yo  Surgical History

PSH:
- 7/24/09: VEPTR insertion on the right side
- 3/5/10: VEPTR lengthening
- 5/29/10: Right acetabular and femoral osteotomy with extensive soft tissue release; Right hip adductor tenotomy; Right hip arthrogram
- 10/1/10: VEPTR lengthening
- 2/4/11: Revision of proximal hardware of VEPTR and revision of femoral osteotomy
- 6/24/11; 1/6/12: VEPTR lengthenings
- 7/10/12: Revision of VEPTR to proximal hooks; insertion of Left rod
- 10/23/12: Revision and lengthening of VEPTR (migration of s hook)
- 6/13/13; 1/7/14; 6/5/14: VEPTR lengthenings

Plan
Stage One: HWR; PCO; Traction
Stage Two: ? VCR and PSIF
“Surgical Misadventure”

- BMI 14
- PGY2 assist;
- Hypotensive Soon After Skin Incision
- Acutely Hypotensive during PCO
- Irrepairable Dural Tear; Fat graft Duraseal

ABORT
“Surgical Misadventure”

• Persistent Wound Drainage

• Infection

• 7 weeks in ICU

• 8 surgeries
• $825,000
# Root Cause Analysis

<table>
<thead>
<tr>
<th>MRN</th>
<th>5074811</th>
<th>PATIENT AGE</th>
<th>9 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENDER:</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRIMARY DIAGNOSIS</td>
<td>Scoliosis</td>
<td>SECONDARY DIAGNOSIS</td>
<td>N/E</td>
</tr>
<tr>
<td>DATE OF SURGERY</td>
<td>8/12/2015</td>
<td>DATE OF FIRST POSITIVE CULT</td>
<td>8/19/2015</td>
</tr>
<tr>
<td>CULTURE SOURCE/SITE</td>
<td>9/3/2015</td>
<td>ORGANISM</td>
<td>Staph ep</td>
</tr>
<tr>
<td></td>
<td>9/3/2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAS PATIENT DISCHARGED AT HOME</td>
<td>NO</td>
<td>WAS WOUND VAC INITIATED</td>
<td>YES</td>
</tr>
<tr>
<td>WAS WOUND NOTED TO DEHISCED?</td>
<td>NO</td>
<td>WHAT POD DID PATIENT PRESENT TO OFFICE/ER/POD?</td>
<td>POD 22</td>
</tr>
<tr>
<td>PRE-OP RISK FACTORS/PERFORMANCE MEASURES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 yrs or older</td>
<td>NO</td>
<td>SUB-OPTIMAL NUTRITIONAL STATUS</td>
<td>BM.I14</td>
</tr>
<tr>
<td>NON-AMBULATORY</td>
<td>YES</td>
<td>INCONTINENT</td>
<td></td>
</tr>
<tr>
<td>PRE-OP BOWEL PREP DONE</td>
<td>NO</td>
<td>PRE-OP URINE CULTURE DONE</td>
<td>YES</td>
</tr>
<tr>
<td>CVS BAIN PREP DONE (MORE NIGHT BEFORE SURGERY)</td>
<td>YES</td>
<td></td>
<td></td>
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<tr>
<td>INTRA-OP RISK FACTORS/PERFORMANCE MEASURES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SURGICAL INCISION TO PELVIS</td>
<td>YES</td>
<td>ESTIMATED BLOOD LOSS</td>
<td>Cell PRBC</td>
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<tr>
<td>RECEIVED BLOOD PRODUCTS</td>
<td>YES</td>
<td>PROLOED OR TIME</td>
<td>YES</td>
</tr>
<tr>
<td>PLASTIC SURGICAL CLOSURE</td>
<td>YES</td>
<td>INTRA-OP BETADINE SOAK X 3 MIN</td>
<td>YES</td>
</tr>
<tr>
<td>VANCOMYCIN POWDER USED IN BONE GRAFT</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRA-OP WOUND IRRIGATION WITH NS AND BETADINE</td>
<td>YES</td>
<td></td>
<td></td>
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<tr>
<td>ACCURATE SS1</td>
<td>YES</td>
<td>INTRA-OP ANTIBIOTIC COMPLIANCE</td>
<td></td>
</tr>
<tr>
<td>INTRA-OP ANTIBIOTIC</td>
<td>YES</td>
<td>CORRECT DOSE</td>
<td>CEFZOLYN + Y/N</td>
</tr>
<tr>
<td>CORRECT INTERVAL</td>
<td>YES</td>
<td>CEFZOLYN + Y/N</td>
<td>TOBRAMYCIN + Y/N</td>
</tr>
<tr>
<td>POST-OP REDOSE OF ANTIBIOTICS INDICATED</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POST-OP RISK FACTORS/PERFORMANCE MEASURES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISRUPTION TO ORGAN POST-OP SPINE DRESSING</td>
<td>YES</td>
<td>FECAL SOILING</td>
<td>YES</td>
</tr>
<tr>
<td>DISRUPTION TO AQUACELL POST-OP SPINE DRESSING</td>
<td>YES</td>
<td>FECAL SOILING</td>
<td>YES</td>
</tr>
<tr>
<td>ACCURATE SS1</td>
<td>YES</td>
<td>POST-OP ANTIBIOTIC COMPLIANCE</td>
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<td>CEFZOLYN + Y/N</td>
<td>TOBRAMYCIN + Y/N</td>
</tr>
</tbody>
</table>
AR- Dural Tear/SSI

Host

Congenital Myotonic Dyst.
Severe Kyphoscoliosis
Multiply Operated
Very Difficult anatomy

Procedures/Indications

Hypotension creates urgency
Attending operating on both sides
Attending operating on both sides

System

Role of “Dual” Surgeons?

Communication

Dural Tear/SSI

Good communication with Anesthesia
Presented in Preop Conference
Beautiful Little Kid ?.... Or Hand Grenade?

EMMA
Emma- RSS 42%

Yes. I got this. Are you sure I'm calling in the reinforcements. Uh my risk severity score is?
What is within our sphere of influence?

**Optimize Host**

- Pre-Operative Surgical Visit
- Risk Stratification
- When to say “no”?
- Preop Optimization

**Eliminate Unnecessary Variability**

- Skin prep, Abx, Irrigation
- Technique, time, closure
- Pathways, Pain Management!

**SYSTEM**

Checklists, Staff, Teams

**CULTURE/ COMMUNICATION**
### Preoperative Screening Tool to Identify High-Risk Patients

<table>
<thead>
<tr>
<th>Clinical Factors</th>
<th>Imaging Factors</th>
<th>Surgical Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Etiology:</strong></td>
<td><strong>X-ray:</strong></td>
<td><strong>Revision surgery</strong></td>
</tr>
<tr>
<td>□ Neuromuscular</td>
<td>□ Large Coronal Cobb Angle</td>
<td>□ Combined anterior and posterior approach</td>
</tr>
<tr>
<td>□ Syndromic</td>
<td>□ Large Kyphosis</td>
<td>□ High number of fusion levels</td>
</tr>
<tr>
<td>□ Congenital</td>
<td>□ Upper thoracic curve</td>
<td>□ Inability to obtain baseline neuromonitoring</td>
</tr>
<tr>
<td><strong>Co-morbidities:</strong></td>
<td>□ High Deformity Angular Ratio (DAR=(\text{kyphosis/# levels}))</td>
<td>□ Vertebral column resection</td>
</tr>
<tr>
<td>□ Cardiopulmonary disease</td>
<td>□ Stiff curve (low flexibility index)</td>
<td>□ Pedicle subtraction osteotomy</td>
</tr>
<tr>
<td>□ Neural axis abnormality</td>
<td>□ MRI:</td>
<td></td>
</tr>
<tr>
<td>□ Skeletal dysplasia</td>
<td>□ Decreased AP cord diameter</td>
<td></td>
</tr>
<tr>
<td><strong>Symptoms:</strong></td>
<td>□ Decreased transverse area of</td>
<td></td>
</tr>
<tr>
<td>□ High rate of symptom progression</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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- Tethered spinal cord
- Large Coronal Cobb Angle

- Osteotomies

- Imaging Factors
- Surgery
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
Development of a Risk Severity Score for EOS

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congenital Etiology</td>
<td>0.969</td>
<td>2.636</td>
</tr>
<tr>
<td>Syndromic Etiology</td>
<td>0.157</td>
<td>1.169</td>
</tr>
<tr>
<td>Cobb &gt; 70°</td>
<td>0.818</td>
<td>2.267</td>
</tr>
<tr>
<td>Hypokyphosis</td>
<td>0.477</td>
<td>1.611</td>
</tr>
<tr>
<td>G-Tube</td>
<td>1.468</td>
<td>4.343</td>
</tr>
<tr>
<td>Non-ambulatory Status</td>
<td>1.067</td>
<td>2.906</td>
</tr>
<tr>
<td>Pulmonary Comorbidity</td>
<td>0.299</td>
<td>1.349</td>
</tr>
</tbody>
</table>

\[
\text{Probability} = \frac{\exp [-4.481 + 0.969(\text{Congenital Etiology}) + 0.157(\text{Syndromic Etiology}) + 0.818(\text{Cobb} > 70°) + 0.477(\text{Hypokyphosis}) + 1.468(\text{G-Tube}) + 1.067(\text{Non-ambulatory}) + 0.299(\text{Pulmonary Comorbidity})]}{1 + \exp [-4.481 + 0.969(\text{Congenital Etiology}) + 0.157(\text{Syndromic Etiology}) + 0.818(\text{Cobb} > 70°) + 0.477(\text{Hypokyphosis}) + 1.468(\text{G-Tube}) + 1.067(\text{Non-ambulatory}) + 0.299(\text{Pulmonary Comorbidity})]}
\]

Predictive Ability 78.4%
There’s an app for that!
Online Risk Severity Score

APP STORE “SSI RSS”
• EOS, NMS, AIS

• Also available at

www.safetyinspinesurgery.org

42.8%
All pre-operative patients receive an RSS score during weekly indications conference

Good afternoon,

CHONY Spine cases for next week. Please feel free to come with questions or concerns. Thank you

-Eduardo

Eduardo C. Beauchamp, MD
Advanced Pediatric Spine Deformity Fellow
Department of Orthopedic Surgery
Columbia University Medical Center
New York, NY
eb3138@columbia.edu
**Classification:**
Kyphoscoliosis

**HPI:** 11M with kyphoscoliosis s/p VEPTR (11/24/2009) which was transitioned to MAGEC (6/26/2015). This was complicated by wound issues and prominent hardware, and subsequent ROH (9/28/2016). He has had very slow or no correction since that point. He is active, plays baseball and has no complaints.

**PMH:**
Scoliosis
Asthma

**Meds:** None

**Physical Exam:**
131cm 28.6kg BMI: 16.7
Incisions healed
Kyphotic deformity
Quite thin

**Imaging:**
Thoracic curve: 80°
Kyphosis is 100°

**RSS:** 3.34%

**Diagnosis:** Kyphoscoliosis

**Plan:** Halo placement

**Equipment:** OSI, halo
To What Degree Does Surgeon Experience Matter? Predicting Risk of Surgical Site Infection in Early Onset Scoliosis

Study Objectives
• To compare predictive abilities between RSS and surgeons

Methods
• Experienced pediatric spine surgeons were surveyed to assess risk of SSI in 15 EOS patient vignettes
• Aggregated prediction was compared to RSS calculator
Results

- Surgeons’ averaged input and RSS predictions were similar in most cases.
- However, there was wide variability among surgeons, suggesting that some surgeons were inaccurately estimating SSI risk.

<table>
<thead>
<tr>
<th>Case #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSS (%)</td>
<td>57.7</td>
<td>5.5</td>
<td>7.2</td>
<td>8.0</td>
<td>24.3</td>
<td>11.4</td>
<td>8.0</td>
<td>30.0</td>
<td>7.6</td>
<td>3.9</td>
</tr>
<tr>
<td>Surgeon Prediction, Average (%)</td>
<td>21.6</td>
<td>6.8</td>
<td>7.1</td>
<td>10.7</td>
<td>25.5</td>
<td>9.1</td>
<td>8.3</td>
<td>20.7</td>
<td>9.2</td>
<td>6.1</td>
</tr>
<tr>
<td>Surgeon Prediction, Range (%)</td>
<td><strong>5-50</strong></td>
<td>1-20</td>
<td>2-16</td>
<td>3-25</td>
<td><strong>3-50</strong></td>
<td>3-20</td>
<td>3-19</td>
<td>10-41</td>
<td>2-19</td>
<td>2-19</td>
</tr>
</tbody>
</table>
Plastic Multilayered Closure in Nonidiopathic Scoliosis

Purpose
• To assess the effect of PMC on SSI and wound complications in patients with non-idiopathic scoliosis undergoing primary or revision instrumentation or fusion.

Methods
• Compare wound complications in standard and plastic multilayered closures to expected risk calculated by RSS
Compared to standard closure, PMC decreased a patient’s risk of SSI by 7.1%.

<table>
<thead>
<tr>
<th></th>
<th>PMC</th>
<th>Standard Closure</th>
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</thead>
<tbody>
<tr>
<td>Observed SSI</td>
<td>1.7%</td>
<td>8.9%</td>
</tr>
<tr>
<td>Expected SSI (from RSS) *</td>
<td>5.6%</td>
<td>5.7%</td>
</tr>
<tr>
<td>Expected vs Observed SSI</td>
<td>-3.9%</td>
<td>+3.2%</td>
</tr>
</tbody>
</table>

\[
\frac{(\text{Expected SSI} - \text{Observed SSI})_{\text{PMC}}}{(\text{Expected SSI} - \text{Observed SSI})_{\text{standard}}} = -7.1\%
\]
RSS: Next Steps

• **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)
Conclusion: RSS in EOS

• Will allow much more “real” informed consent with family

• Allows us to “slow the line”, and optimize patient preop

• Allows consideration of different surgical approach (2 surgeons, limited goals, consider saying no)
5th Annual Safety in Spine Surgery Summit
Transforming Patient Care and Optimizing Outcomes

Friday March 13, 2020
New York City

Chair:
Michael G. Vitale, MD, MPH
Co-Chairs:
John M. Flynn, MD
Roger Hartl, MD
Lawrence G. Lenke, MD
Rajiv K. Sethi, MD

An Essential program for:
- Spine surgeons
- Surgical spine team members
- Hospital execs responsible for patient safety

Registration will open in Fall 2019
On Behalf of Our Patients, THANK YOU!