What Every Surgeon Needs To Know About Pulmonary Issues in EOS

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Disclosures

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Pulmonary Features of Early Onset Scoliosis

- Low Lung Volumes*
- Chest Wall Distensibility and Excursion
- Respiratory Muscle Force and Movement

Hypoxemia
- Poor sleep
- Cor pulmonale

- Work Tachypnea
- + Poor Growth
- ↓ Exercise Tolerance
- Respiratory Failure

Poor Growth

Exercise Tolerance

Respiratory Failure
General Principles of Care

- Progressive deformity leads to decline in respiratory function.
- Current surgical interventions preserve but do not restore lung function.
- Early intervention (surgical vs non-surgical) to prevent deformity will likely improve potential for lung development and growth.
More Principles

- Age at fusion impairs further growth of the thorax, and hence lung function.
- Lung function declines as adults age.
- Pulmonary status (and loss of reserve) will likely influence life span and quality of life.
Pulmonary Epochs of Care for Thoracic Insufficiency Syndrome

Pre-operative Era…..
(includes non-surgical options, e.g. casting)

- Initial Respiratory Severity Assessment
- Diagnosis of Co-morbidities
- Provision of Resp. supportive care
- Monitor Progression of Respiratory status
- Philosophy of Care Pre-surgical Rx
Pulmonary Epochs of Care (con’t)

Operative Era.....
- Assess changes after surgery
- Assess timing of expansions
- Strategize for timing of fusion

Post-Surgical Treatment Era.....
- Provide medical home for chronic pulmonary management
- Arrange transition to adult care
Two Lung Volumes: FVC and RV in EOS

- **Forced Vital Capacity (FVC)** reflects:
  - Intrathoracic Volume
  - Chest Wall Mobility
  - Resp. muscle function

- **Residual Volume (RV)** reflects:
  - Gas Reservoir left after complete exhalation

- **FVC**
  - 62 ± 4%
  - N=53
  - TIS-pre-op

- **RV**
  - 77 ± 12%
  - TLC

Effects of EOS on Breathing During Sleep

AHI

Nadir SaO₂

Un-Treated

Treated

NL
Lung Volumes Before and 6 Months After Device Implantation*

- **Normal**
  - TLC
  - FRC
  - RV
  - RV
  - FVC: 77 ± 12%

- **TIS-pre-op**
  - RV
  - FVC: 62 ± 4%

- **TIS-post-op**
  - RV*
  - FVC: 54 ± 3%
  - RV*: 96 ± 16%

- n=53


* n=12
### Increase in FVC After VEPTR Use: Effect of Age

<table>
<thead>
<tr>
<th>Age at Surgery</th>
<th>$N$</th>
<th>Increase in FVC per year*</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6 years</td>
<td>16</td>
<td>14.7 +/- 8.5%</td>
</tr>
<tr>
<td>&gt; 6.5 years</td>
<td>7</td>
<td>6.5 +/- 5.5%</td>
</tr>
</tbody>
</table>

*in absolute liters of lung volume

Pre vs Post-op Vital Capacity after Spine Fusion for AIS


N=254
Chest Wall Compliance Declines With Age in Normal Children

Chest wall compliance falls by 30% from 5 to 16 years of age.

Effects of deformity and immobility over years?

Rotation Before and After Growing Rod Insertion

Chest Wall Compliance in Children with EOS

• Chest wall compliance is reduced:
  • With post-natal age
  • With progressive chest wall and spine deformity
  • With combined metal implants in the chest and spine?
Inspiratory Respiratory Muscle Disorders

- Weakness
- Fatigability
- Position
- Excursion
- Scoliosis

Reduced Respiratory Muscle Strength in EOS and AIS

Reduced Intercostal Motion → Diaphragm Dependence

Reduced Diaphragm Excursion → Reduced Vital Capacity

Overall Respiratory Effects* of Current Treatments of EOS

• Lung and Intrathoracic volumes +
• Chest Wall Compliance -
• Respiratory Muscle functions no change

*Most effects unstudied to date for different treatments
Pulmonary Responses to Surgical Treatment of EOS by Lung Volumes

Vital Capacity + Residual Volume = Total Lung Capacity
What are the Pulmonary Targets for “Good” Outcomes?

- American Thoracic Society definition of “disability” in adults:

  Moderate impairment:
  - Impairment sufficient to diminish ability to perform normal jobs: FVC = 50-59% predicted
  - Mild impairment: FVC = 60-79% predicted

Summary

• Current surgical treatments increase lung volumes enough to almost keep up with somatic growth.

• Early non-surgical interventions that also reduce rotation may preserve lung function better than surgical distraction alone.

• New multi-disciplinary approaches are needed to recover lung function already lost due to scoliosis.