What Every Surgeon Needs To Know About Pulmonary Issues in EOS

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Disclosures

Editor for Pediatric Pulmonary section of UpToDate.

Pulmonary Features of Early Onset Scoliosis

↓ Low Lung Volumes* → Hypoxemia, Poor sleep, Cor pulmonale

↓ Chest Wall Distensibility and Excursion → ↑ Work, Tachypnea, + Poor Growth, ↓ Exercise Tolerance

↓ Respiratory Muscle Force and Movement → 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)

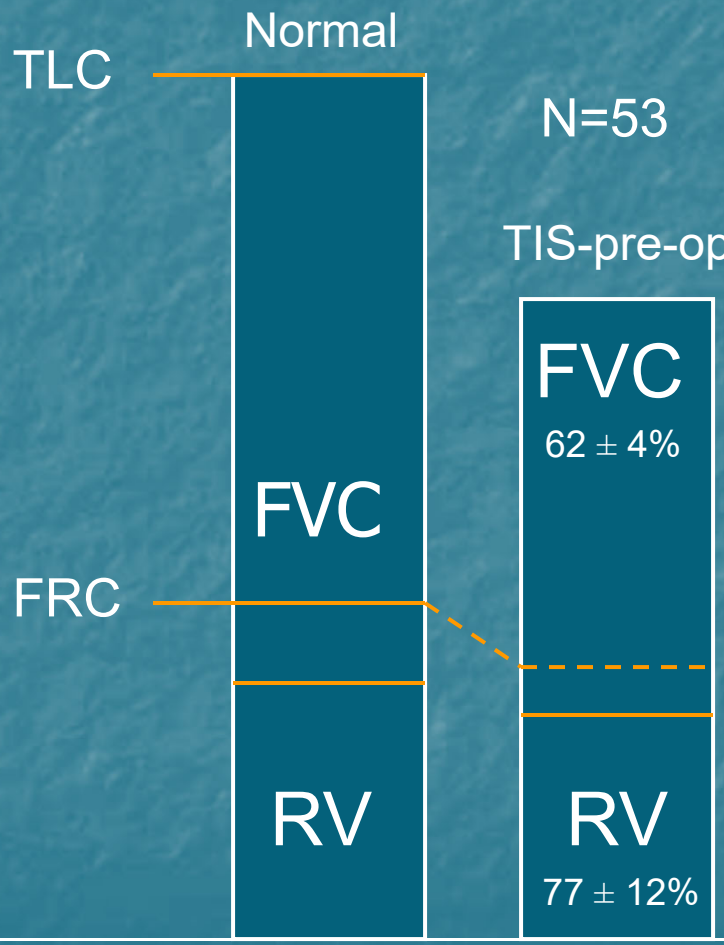
Operative Era.....

- 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

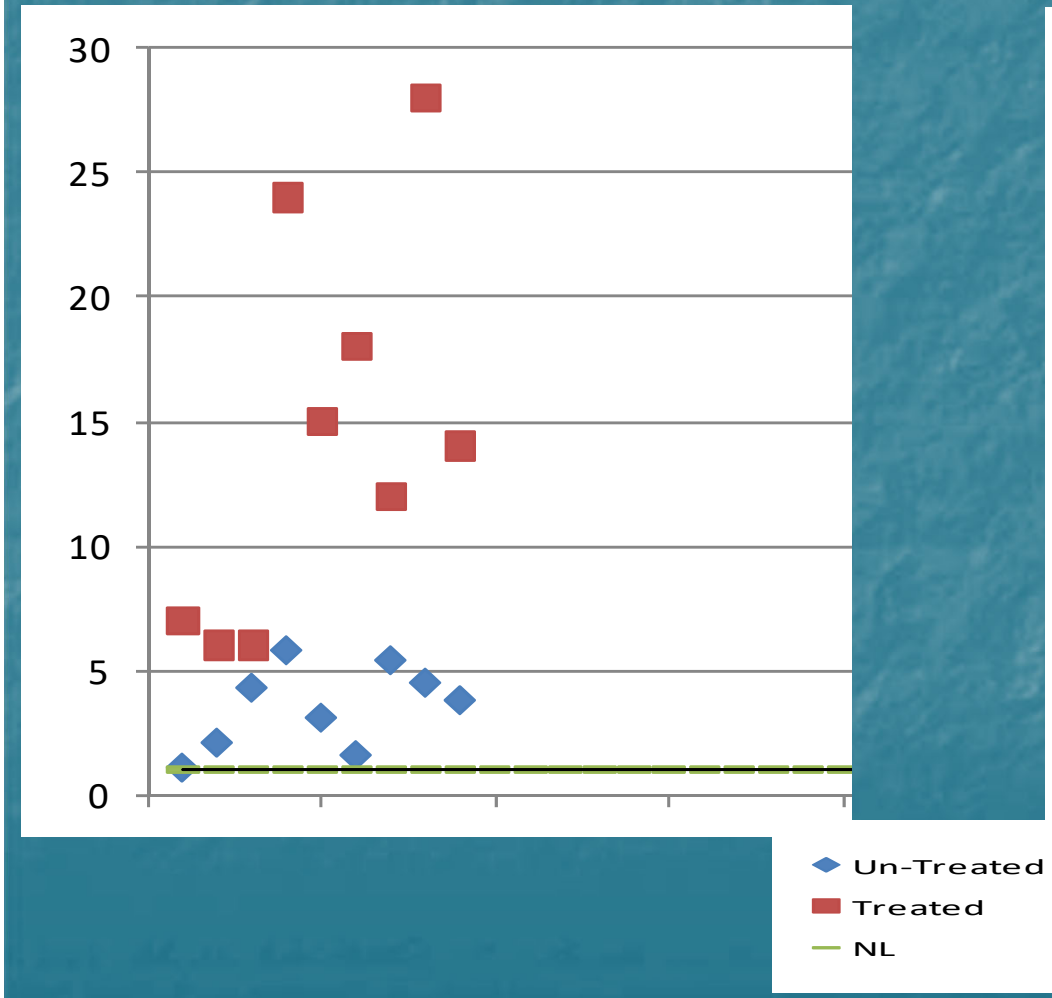


- Forced Vital Capacity (FVC) reflects:
  - Intrathoracic Volume
  - Chest Wall Mobility
  - Resp. muscle function
- Residual Volume (RV) reflects:
  - Gas Reservoir left after complete exhalation

Mayer OH, Redding GJ *Pediatr Orthop* 29(1):35-38, 2009.

Effects of EOS on Breathing During Sleep

AHI



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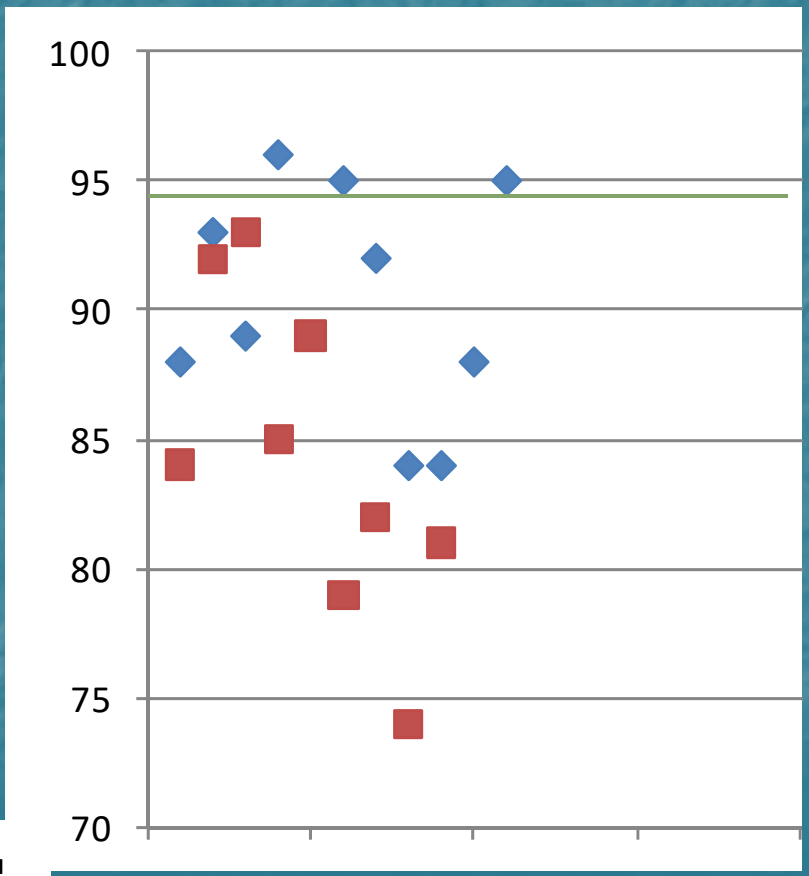
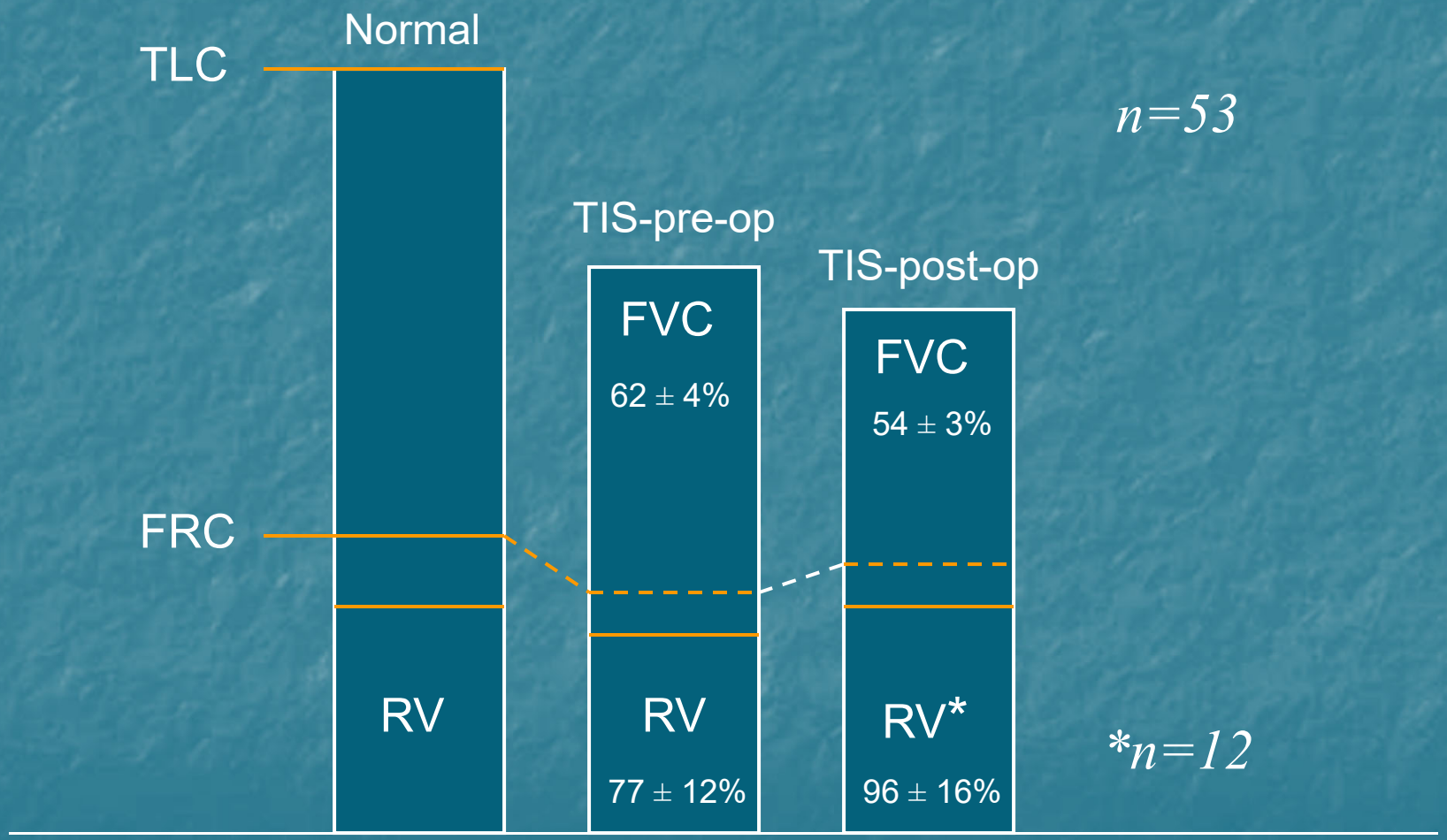


Lung Volumes Before and 6 Months After Device Impantation*



Mayer OH, Redding GJ *Pediatr Orthop* 29(1):35-38, 2009.

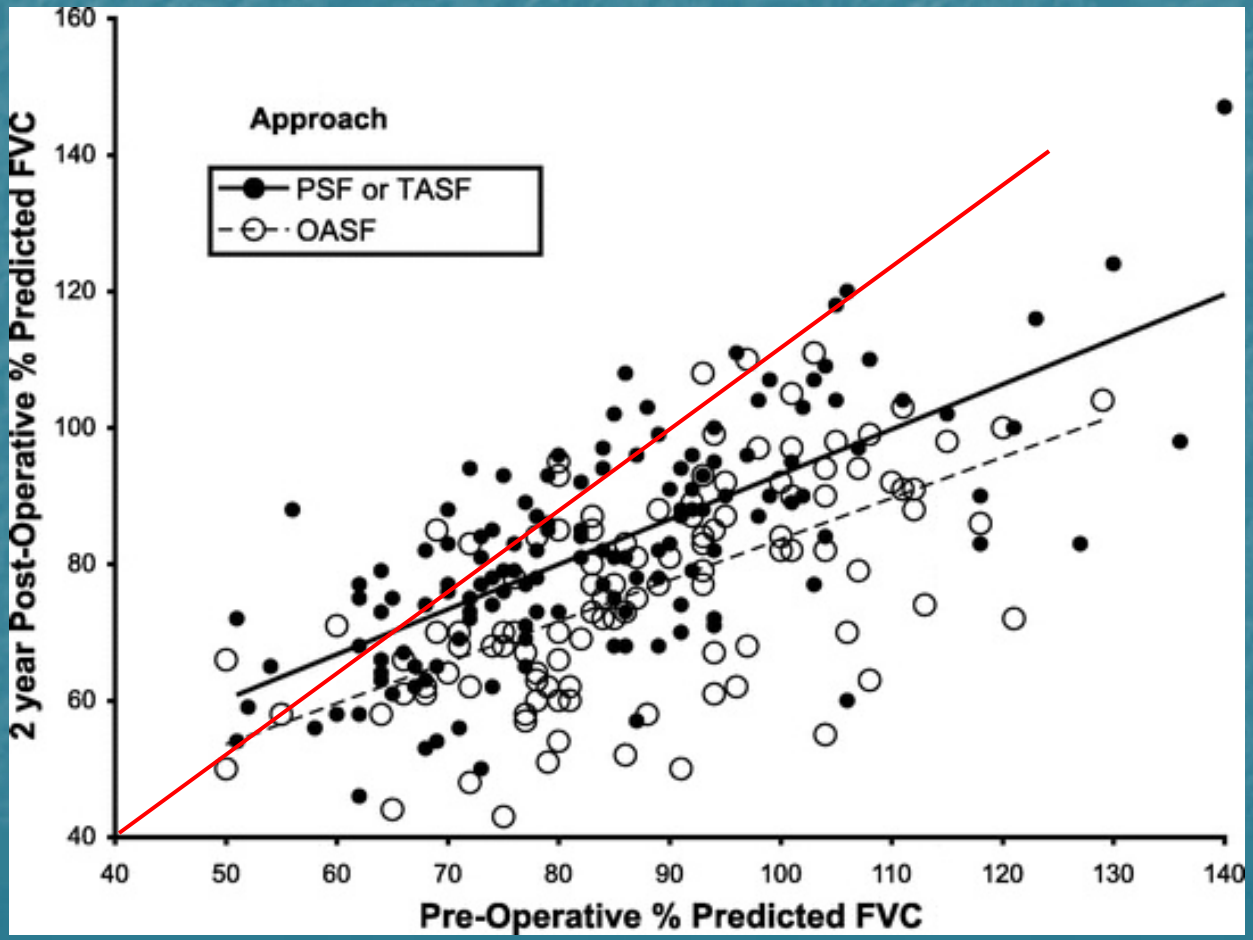
Increase in FVC After VEPTR Use: Effect of Age

Age at Surgery	*N*	Increase in FVC per year*
< 6 years	16	14.7 +/- 8.5%
> 6.5 years	7	6.5 +/- 5/.5%

*in absolute liters of lung volume

Motoyama et al. *Paed Resp Rev* 10:12-17, 2009.

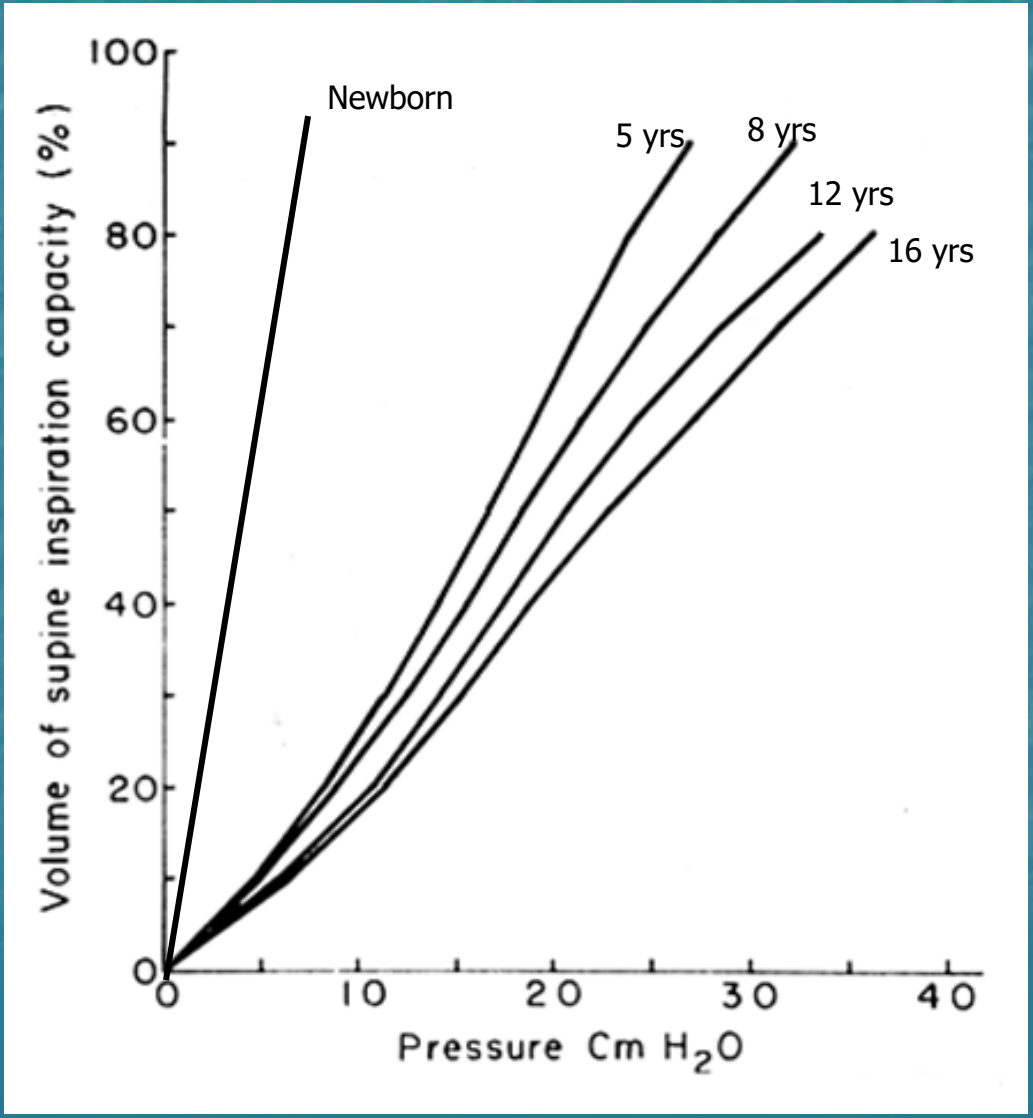
Pre vs Post-op Vital Capacity after Spine Fusion for AIS



N=254

Newton PO, et al. *Spine* 32(17):1875-1882, 2007.

Chest Wall Compliance Declines With Age in Normal Children

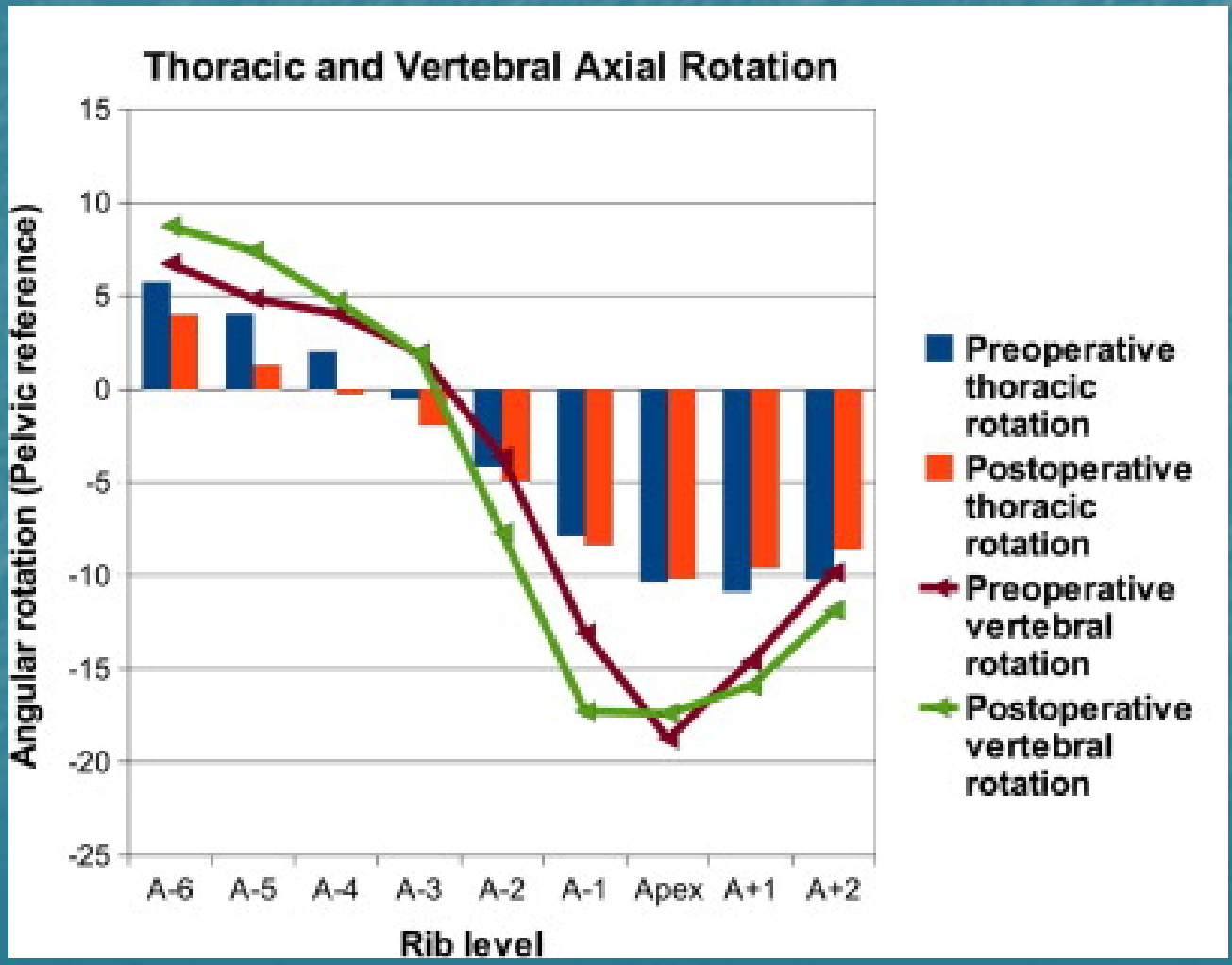


Chest wall compliance falls by 30% from 5 to 16 years of age

Effects of deformity and immobility over years?

Sharp et al. *J App Physiol* 29:775, 1970.

Rotation Before and After Growing Rod Insertion

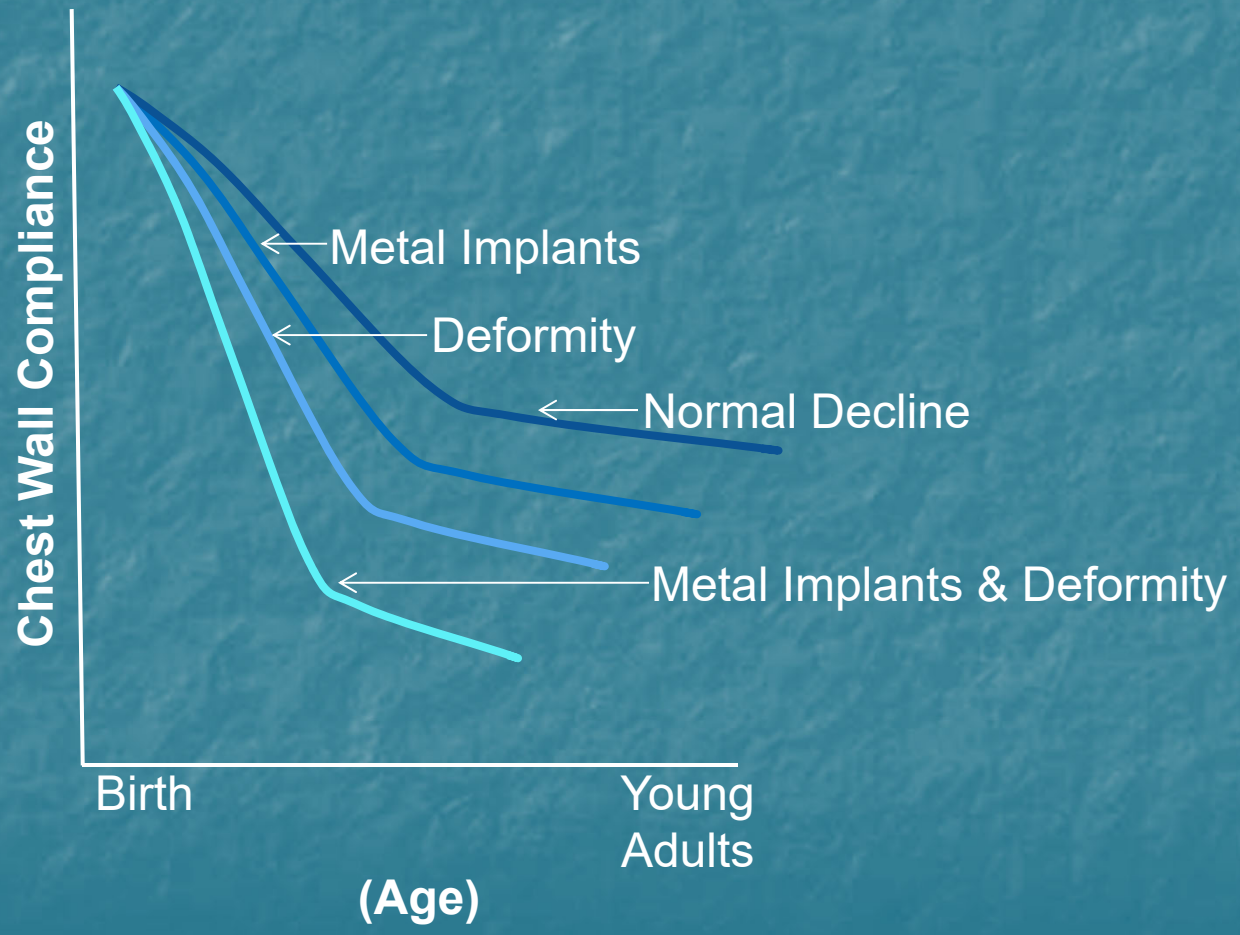


N=4

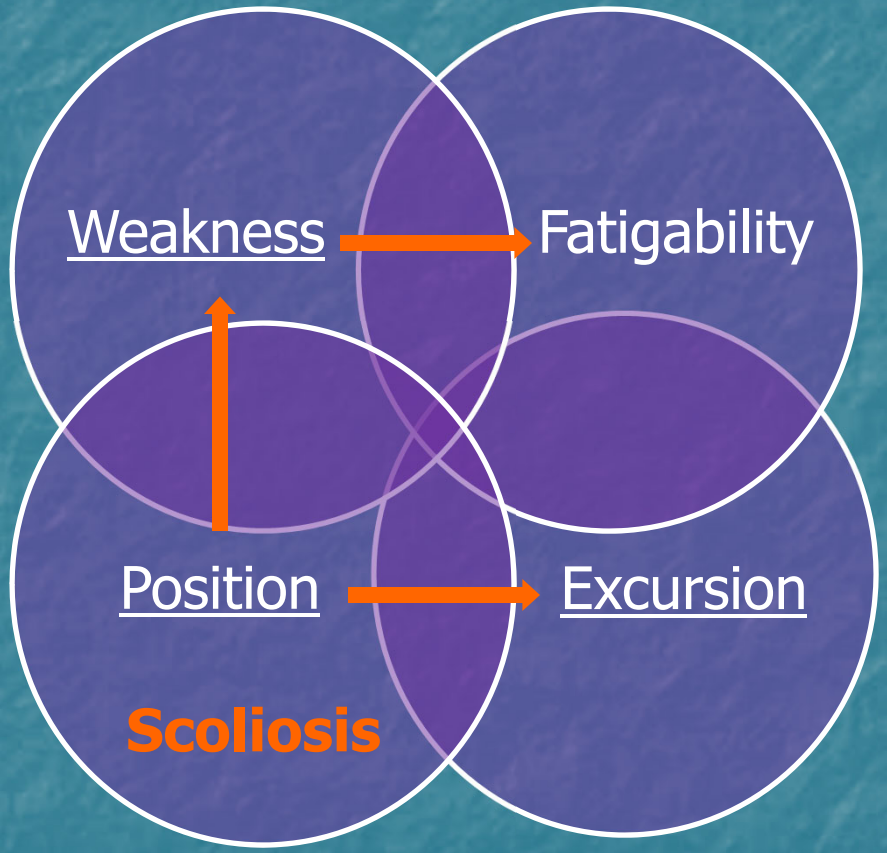
Sabourin M, et al. *Clinical Biomechanics* 25:284-291, 2010.

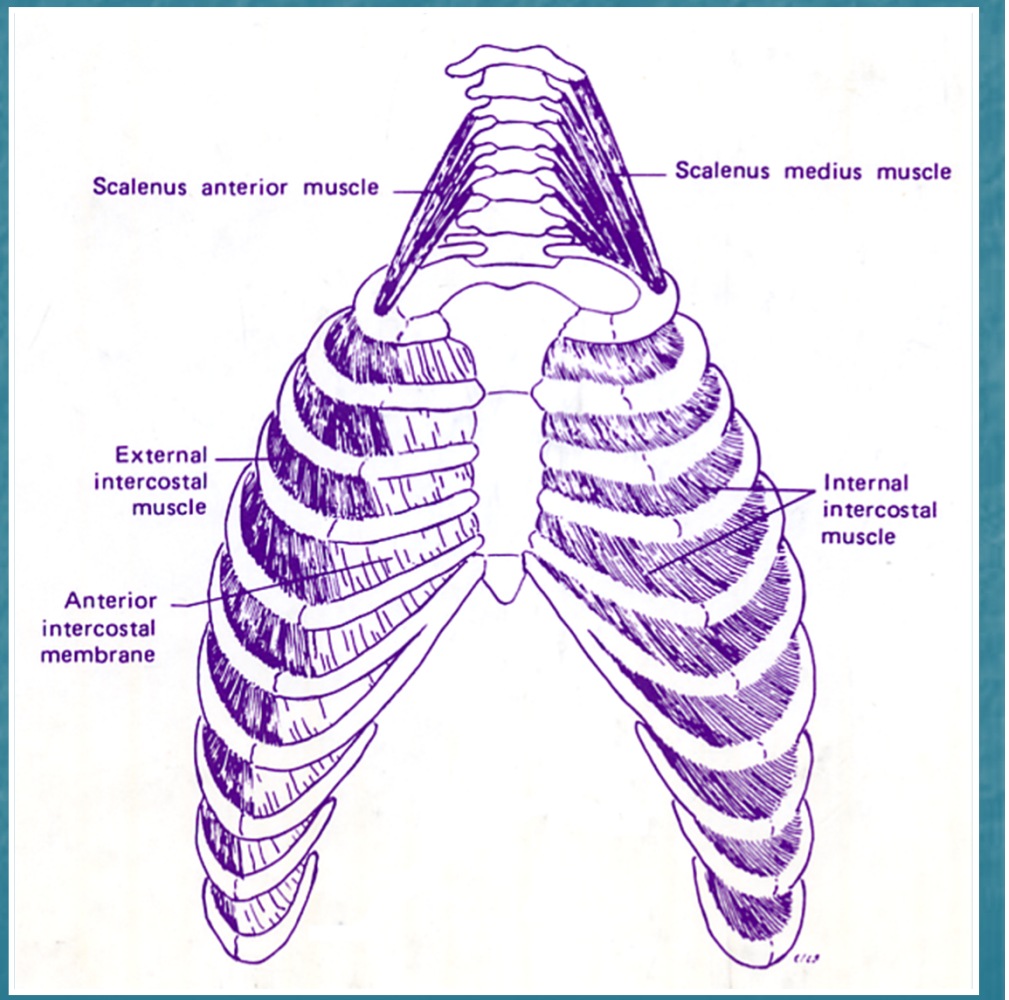
Chest Wall Compliance in Children with EOS

- 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



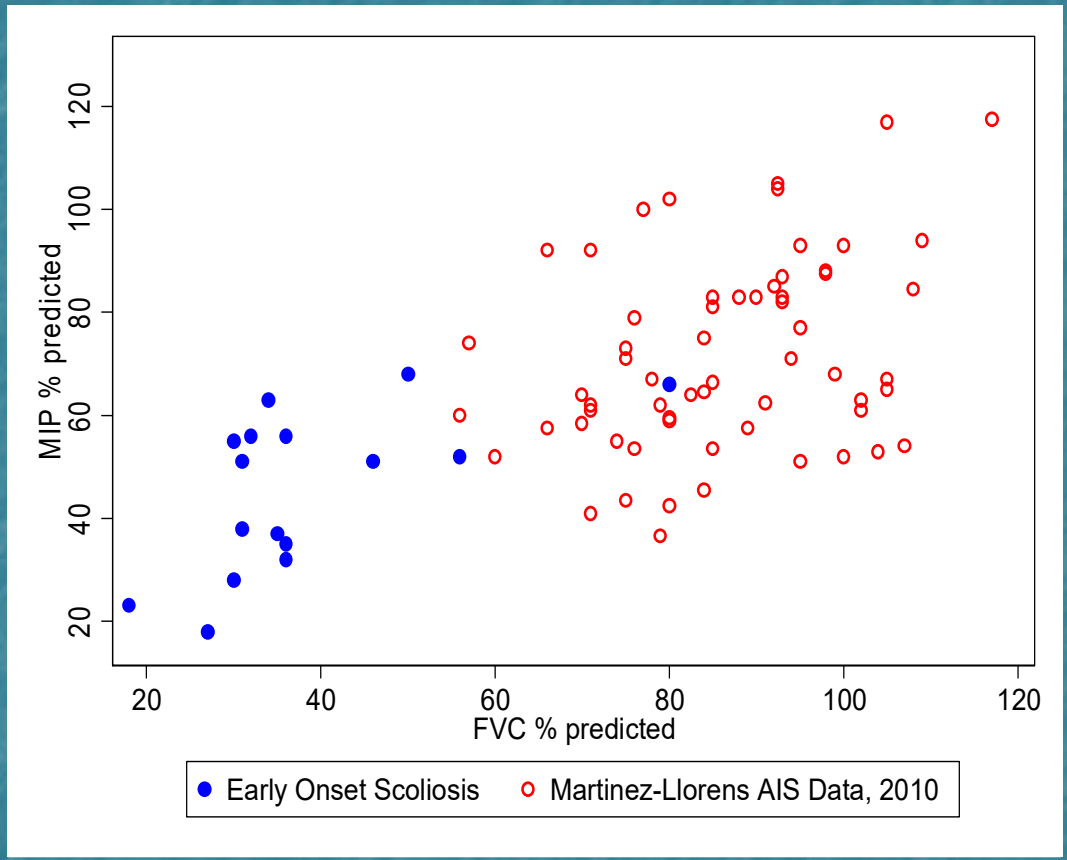


Roussos C, Macklem PT. In: The Thorax (vol 29):Marcel Dekker, Inc., 1984.

Reduced Respiratory Muscle Strength in EOS and AIS

Reduced Intercostal Motion → Diaphragm Dependence

Reduced Diaphragm Excursion → Reduced Vital Capacity



Moreno LC, et al. *Am Rev Respir Dis* 132(1):48-52, 1985.
Martinez-Llorens et al. *Eur Resp J* 36(2):393-400, 2010.
Redding G, et al. ICEOS, 2012.

Inspiration

Expiration

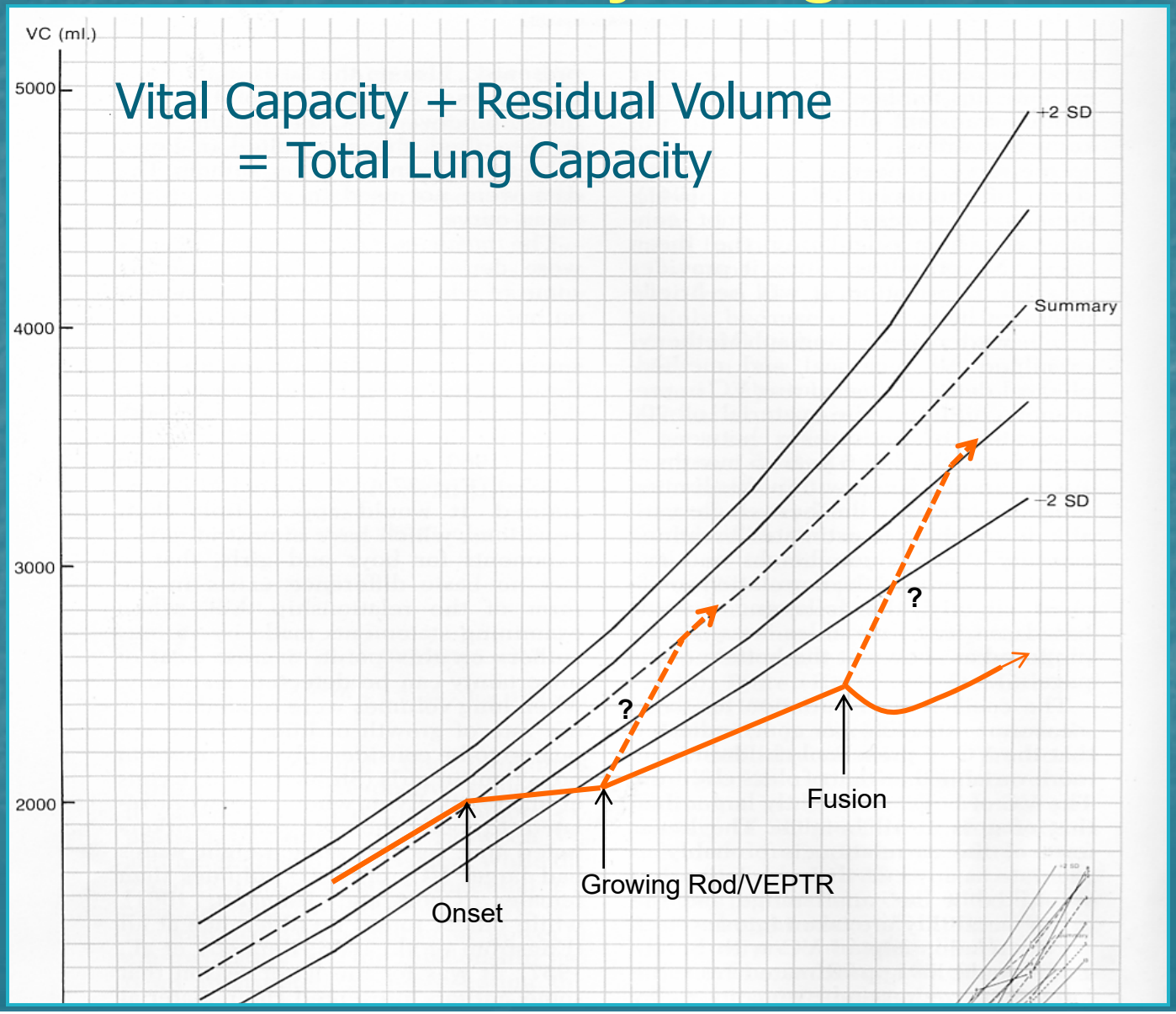
Kondo T, et al. *Respirology* 5:19-25, 2000.
Cluzel P, et al. *Radiology* 215:574-583, 2000.

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



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

Johnston CE, et al. *Spine* 36 (14); 1096-1102, 2011.

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.