Postnatal Lung Growth and Lung Function Growth

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Disclosures

Chest Wall and Spine Deformity Foundation

Lung Issues in EOS

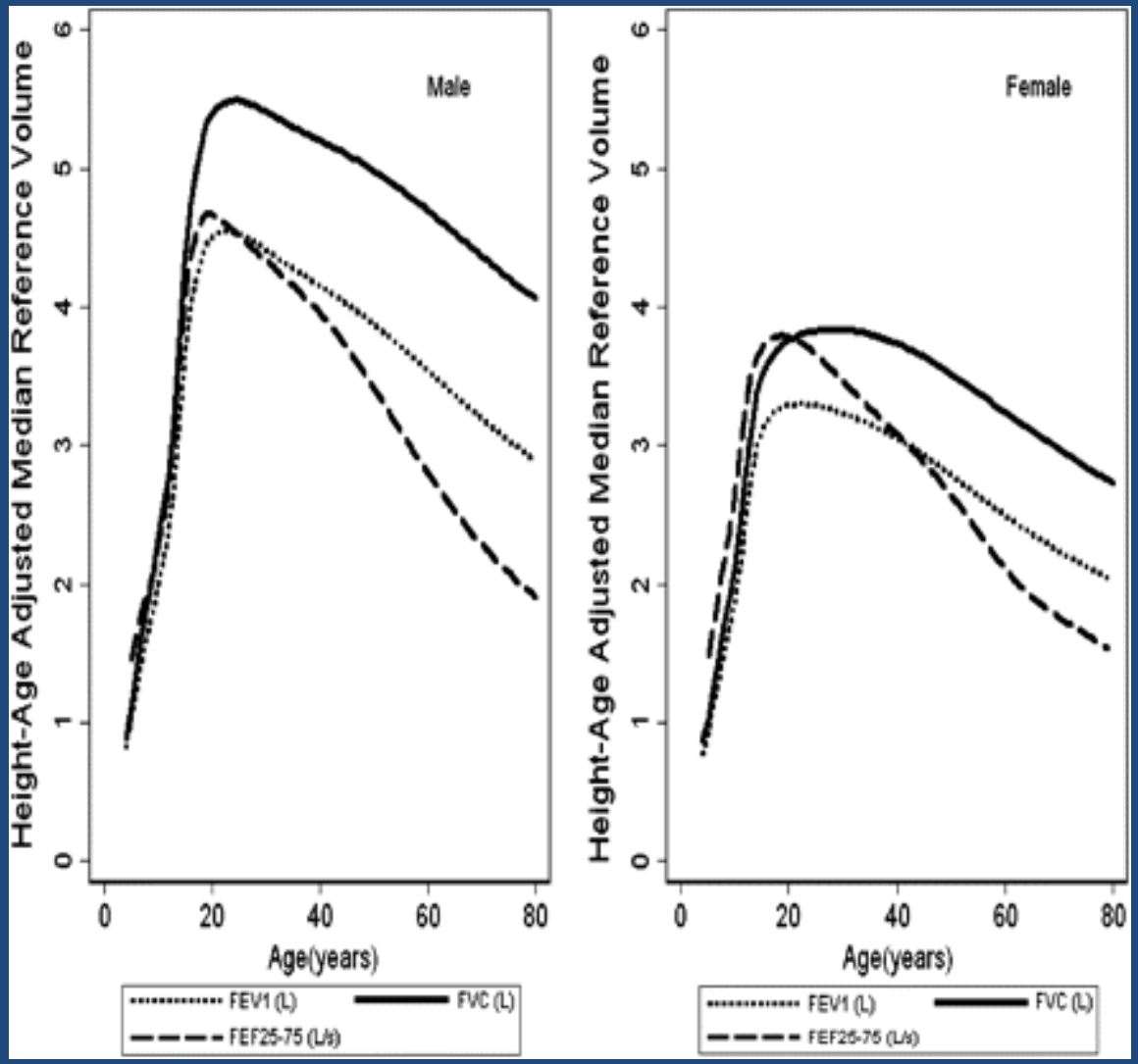
- EOS leads to restrictive chest wall and lung disease which reduces respiratory reserve as it progresses.
- “Growing” devices are now used to prevent progressive restrictive lung disease but do not recover what pulmonary reserve that is lost.
- Timing of different interventions ideally prevents loss of lung function but provides the maximal correction when devices are finally inserted.

Pulmonary Changes From Neonatal Period to Adulthood

	Adult/Neonatal Ratio
Bronchial Diameter	2.5
Bronchial & Bronchiolar Number	1
Alveolar Number	12.3
Alveolar Size*	5.5
Alveolar-capillary surface area	10-15
Vital capacity	25-32

All increase respiratory reserve needed for exercise, sleep and illness

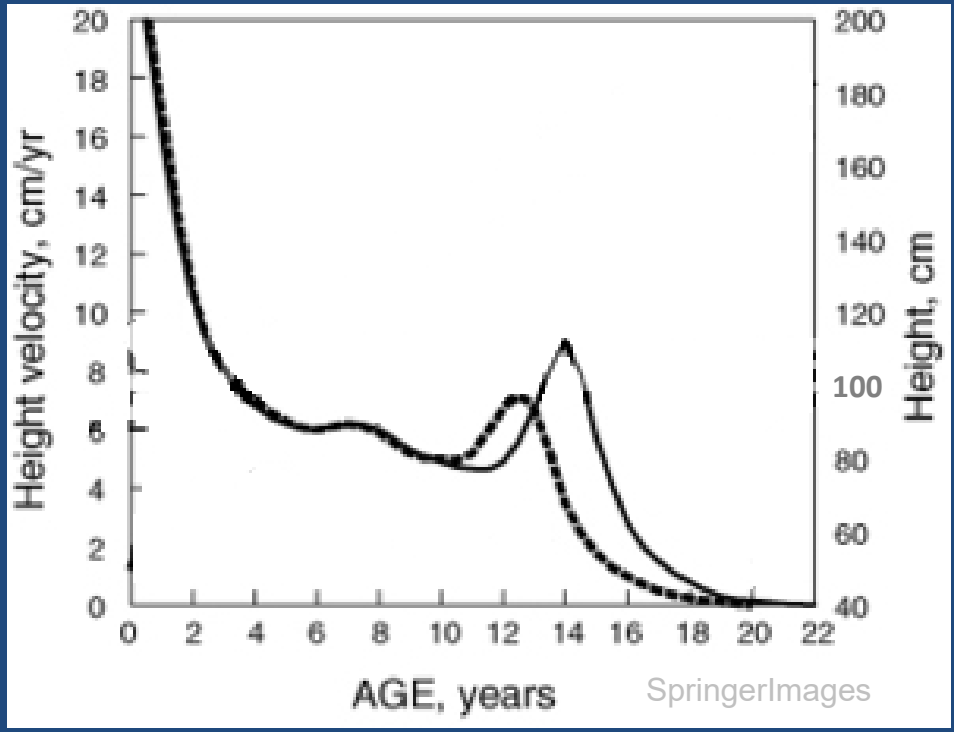
Lung Function Growth in Normal People



Stanojevic S et al. *Am J Respir Crit Care Med* 177:253-260, 2008.

Eras in Postnatal Respiratory Development based on growth velocity

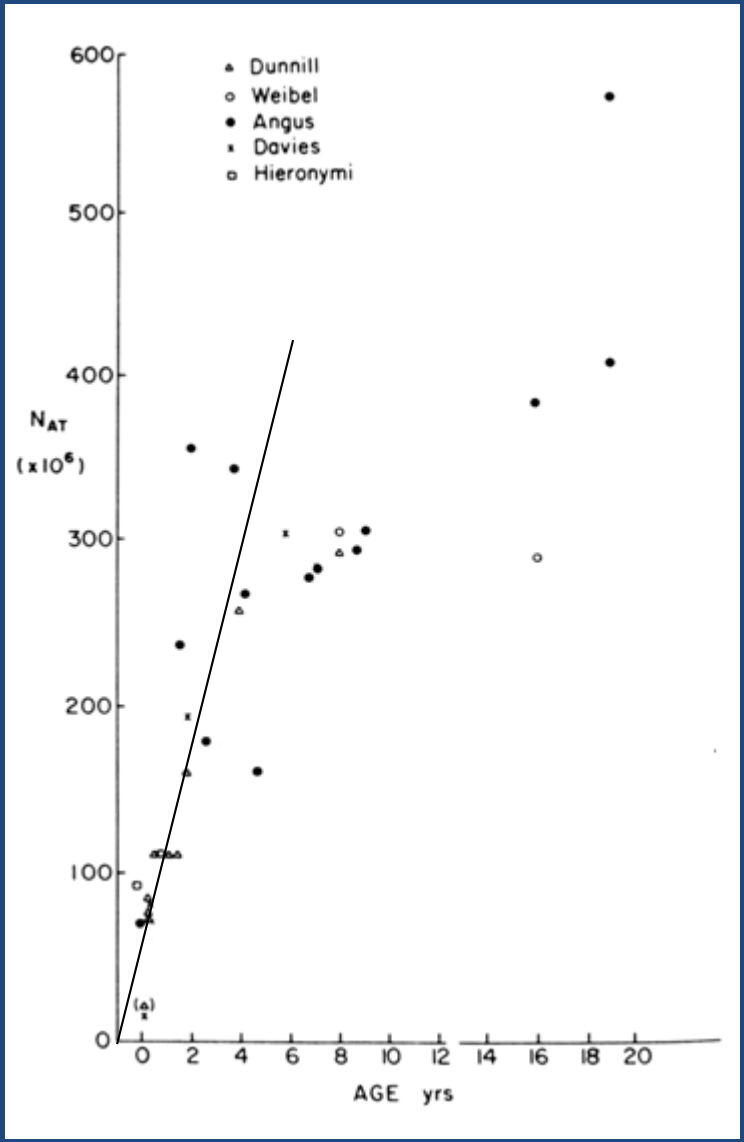
- Neonatal through Infancy
- Adolescence to Young Adulthood
- Aging Adults



Neonate -3 Years of Age

Opportunity:	**Rapid somatic growth**	**Rapid increase in alveolar number and complexity**	**Rapid vertebral growth**
Risk:	**Acute lower tract infections common**	**Pulmonary mechanics ineffciency**	**Greatest risk of morbidity and mortality from respiratory etiologies**

Postnatal Lung Development: Alveolar Number

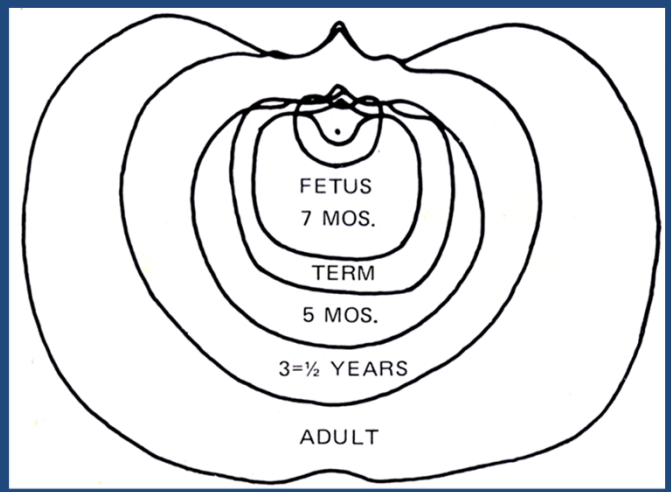


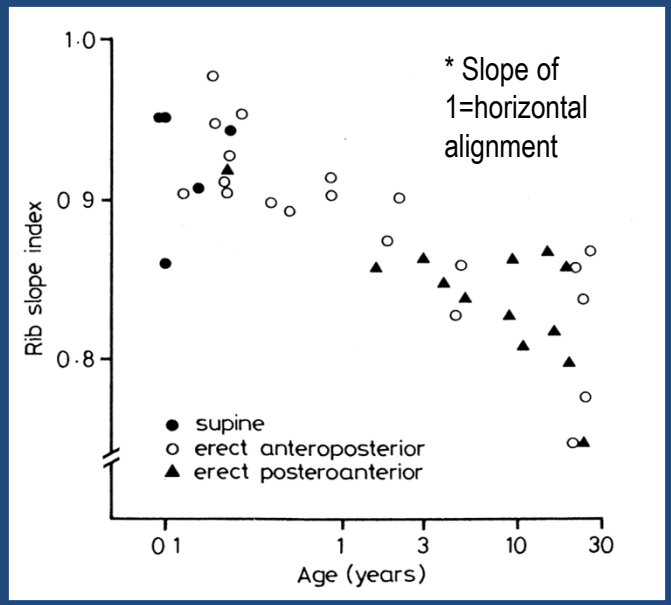
Alveolar number increases with somatic growth

Alveolar growth is more rapid in children <2 years of age and maybe < 4 years

Murray JF. In: The Normal Lung (2nd Ed.), W.B. Saunders, Philadelphia, 2:23-60, 1986.

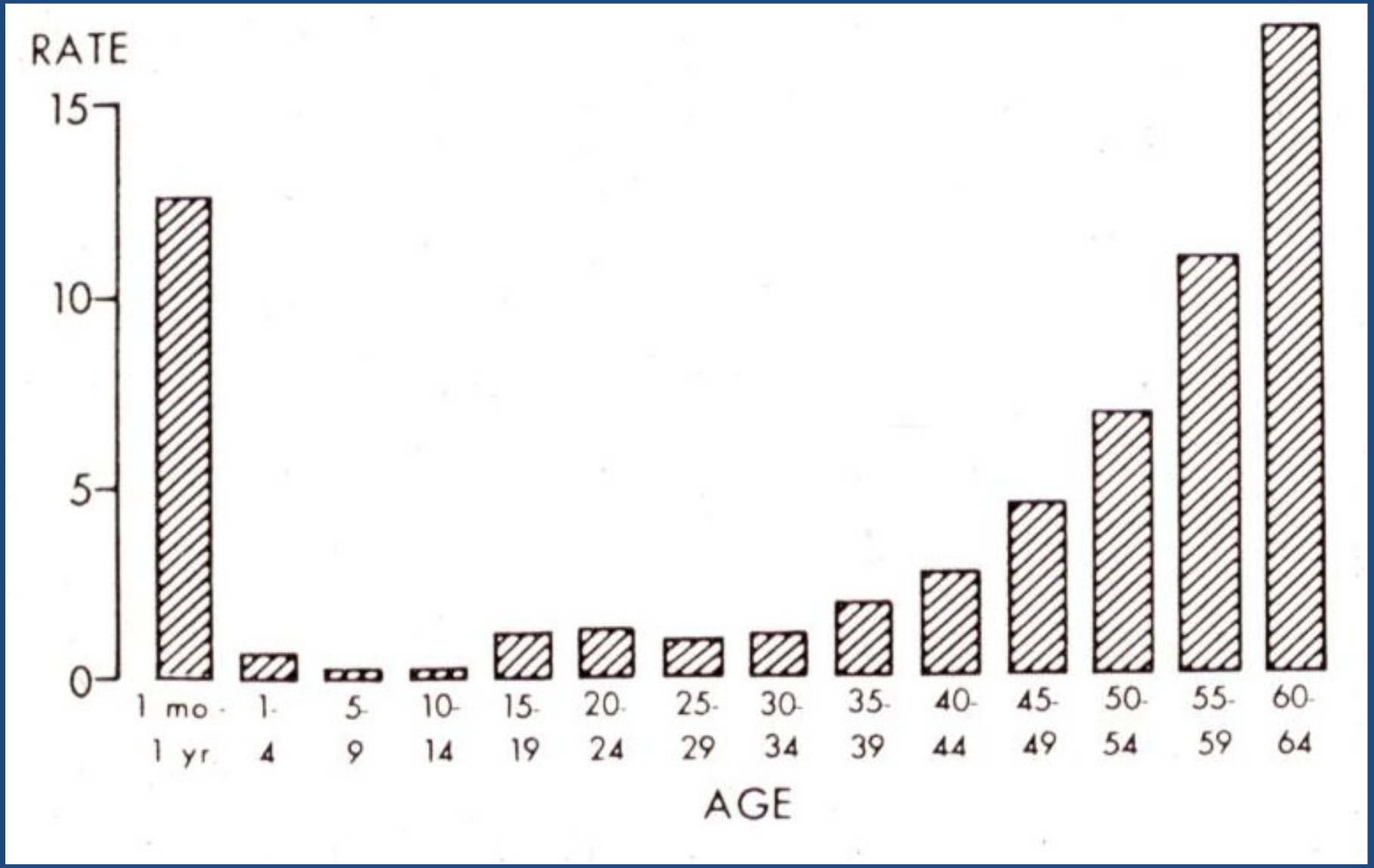
Developmental Thoracic Features Impacting Respiratory Muscle Function





Bryan AC, Gaultier C. In: The Thorax (Vol 29) Ed. Roussos C, Macklem PT, 1985; Marcel Dekker, Inc.

Risk of Death Due to Respiratory Causes



Newth C et al. In:The Pediatric Clinics of North America 26(3):617-643, 1979.

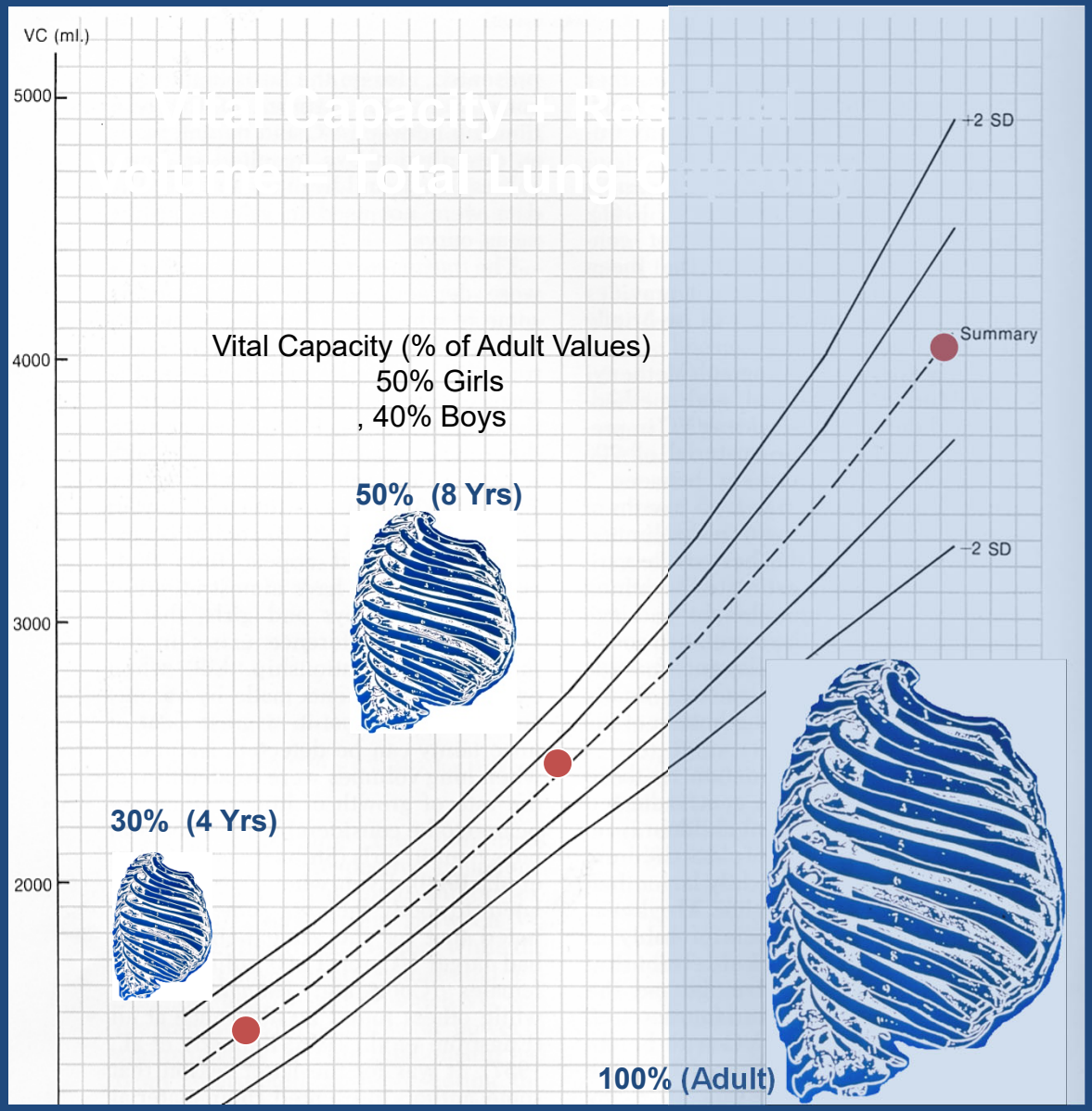
Adolescent to Adult

Opportunity:	**Increase in Alveolar size**	**Increase respiratory muscle strength**	**Optimal lung mechanics/reserve**
Risk:	**Less Compensatory Lung Growth?**		

Does this influence the optimal time of spine fusion?

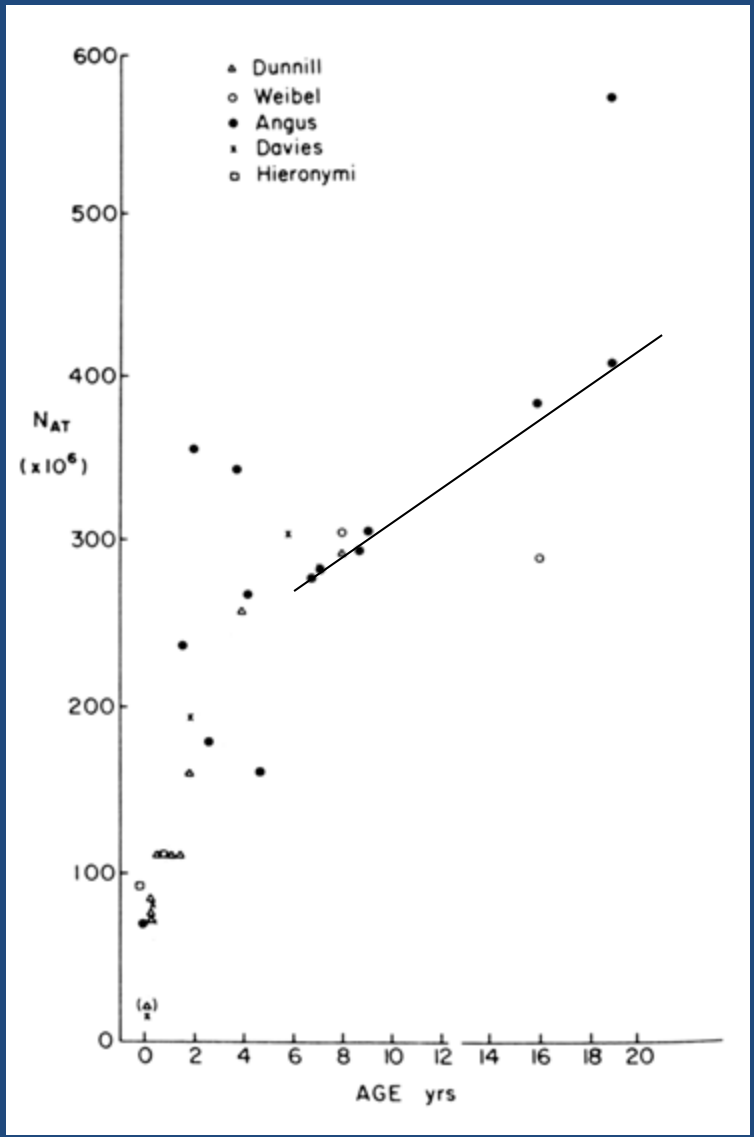
Lung and Thoracic Cage Volumes: Changes During Adolescence

Total Lung Capacity



Serial measure of lung function growth in EOS have not been published.

Postnatal Lung Development: Alveolar Number

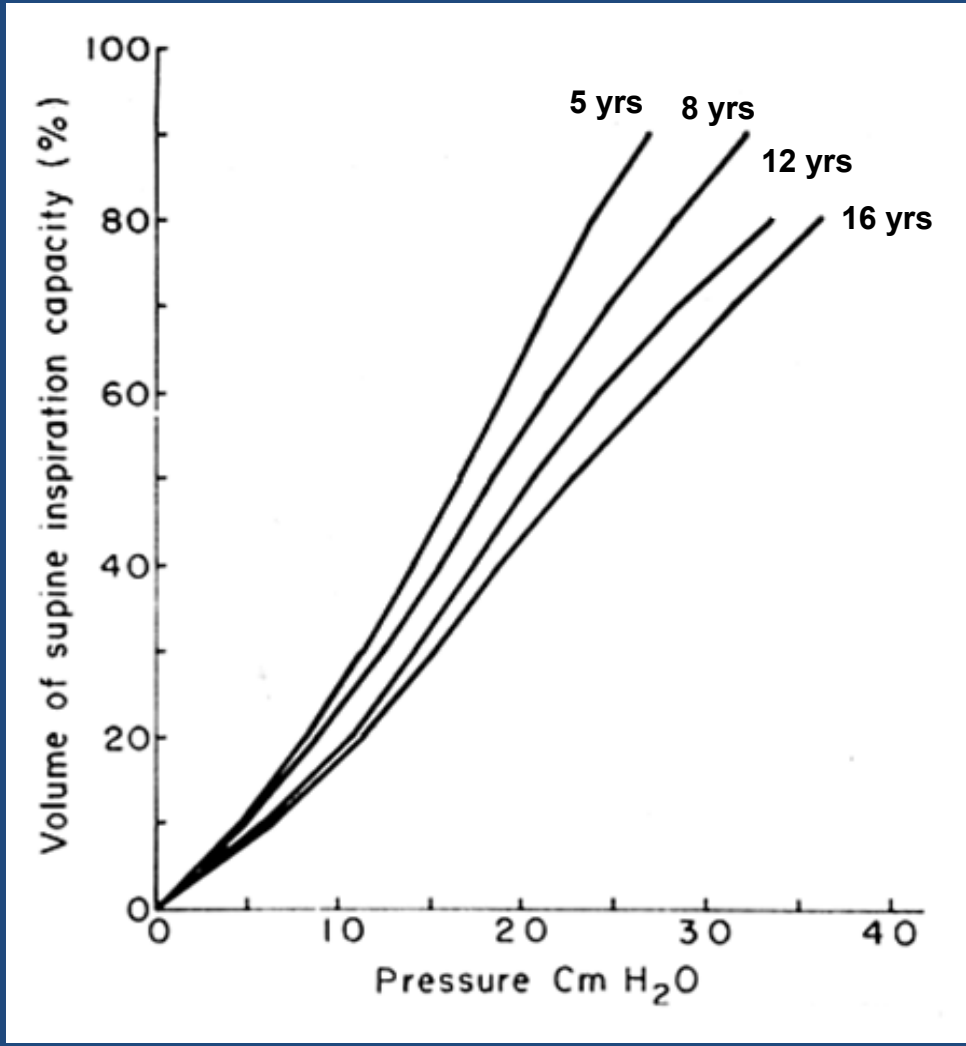


Alveolar number increase with somatic growth

Alveolar size increases more than number in older children

Murray JF. In: The Normal Lung (2nd Ed.), W.B. Saunders, Philadelphia, 2:23-60, 1986.

Changes in Chest Wall Compliance With Age in Normal Children



Compliance falls by 30% from 5 to 16 years of age

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

Normal values of maximal inspiratory pressure (Pi_{max}) at residual volume and expiratory pressures (Pe_{max}) at total lung capacity

Age	Pi_{max}*		Pe_{max}	
	Male	*Female*	*Male*	*Female*
8	77 ± 24	71 ± 29	99 ± 23	74 ± 25
10	105 ±27	71 ± 29	123 ± 27	74 ± 25
11-13	114 ± 27	108 ± 29	161 ± 37	126 ± 32
13-17	126 ± 22	109 ± 21	166 ± 44	135 ± 29

*MIP in EOS ranges from 30-60 cmH_2O

Fauroux B. *Paediatric Respiratory Reviews* 4:243-249, 2003.

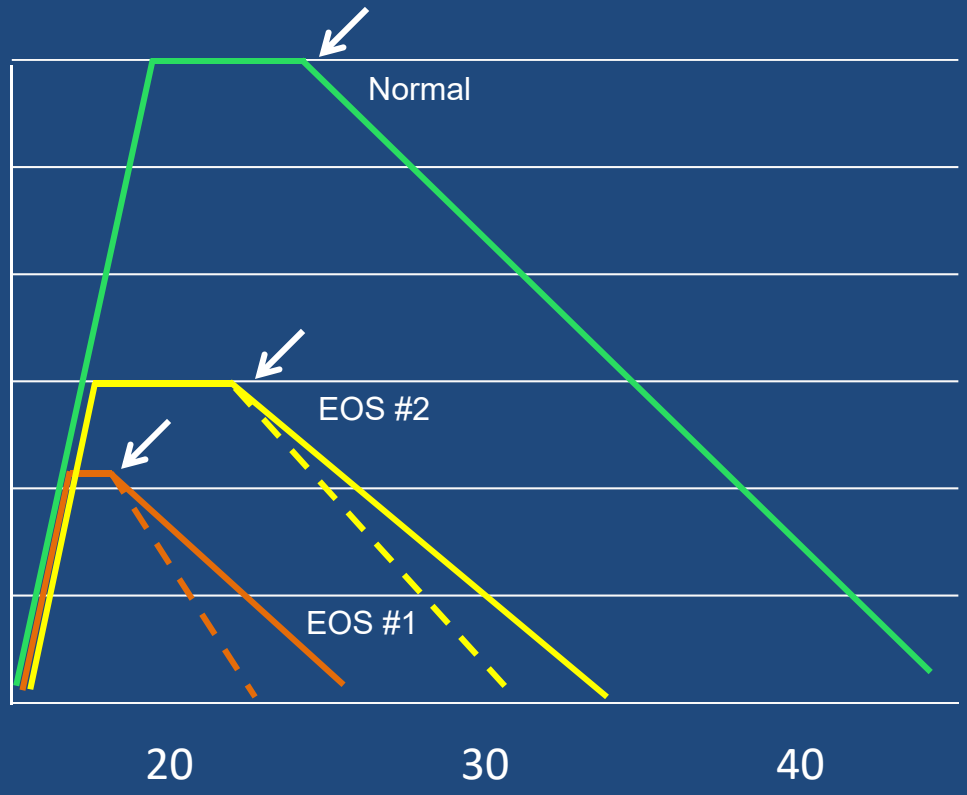
Respiratory Effects of EOS: Impact on Lung Function Growth in Adulthood

Low Lung Volumes

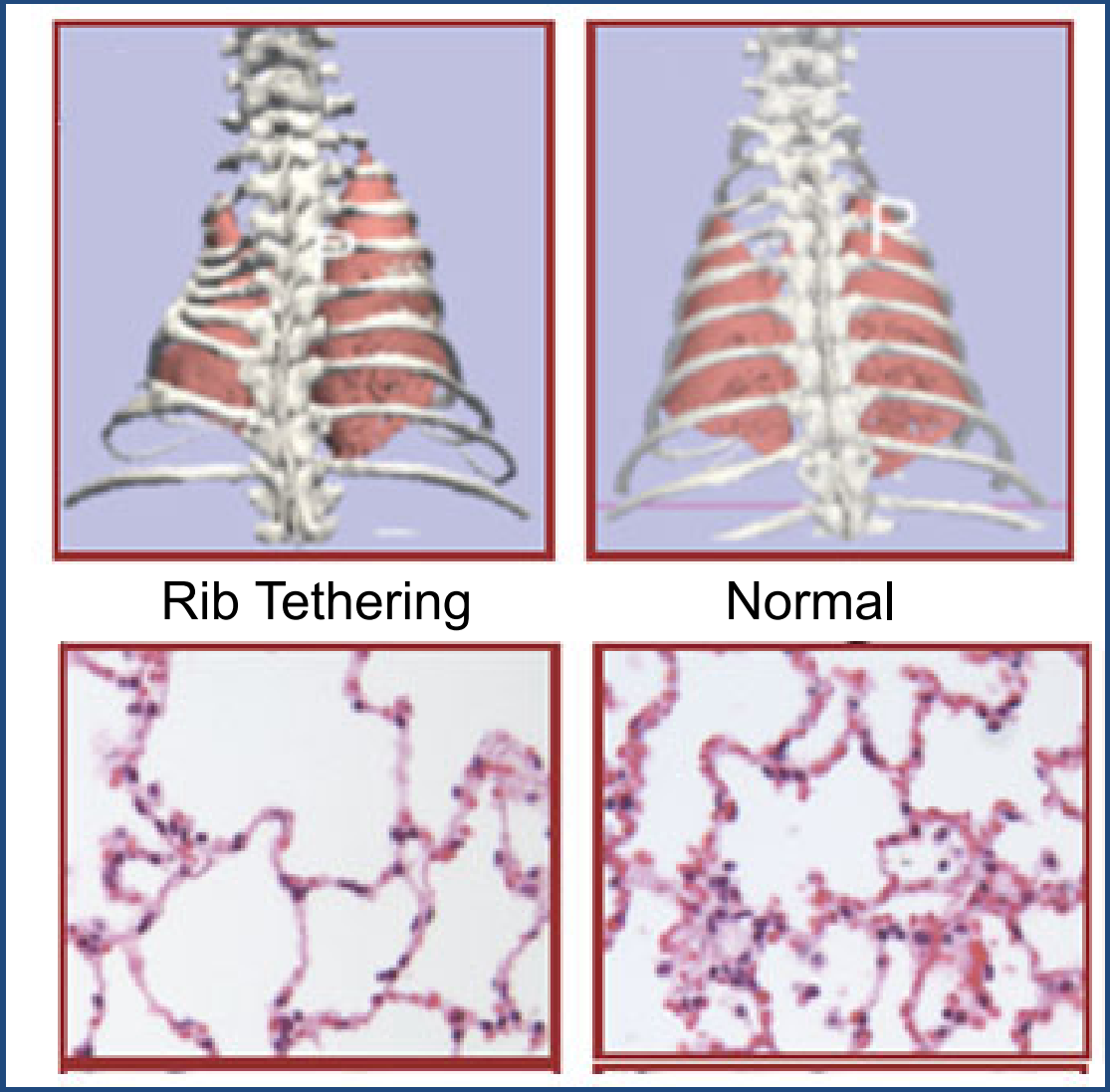
Reduced Chest Wall Distensibility and Excursion

Reduced Respiratory Muscle Force and Movement

Constrained Postnatal Lung Growth



Chest Wall Constraints: Post-natal Pulmonary Hypoplaisa Syndrome?



Olson JC, Kurek KC, Mehta HP, et al. Evaluation of Pulmonary Cellular Response to Treatment of thoracic Insufficiency Syndrome Using Expansion Thoracoplasty in Scoliotic Rabbit Model

Important Questions Remain

- Can compensatory lung growth happen in humans? Probably but not the same growth patterns or growth signals as with normal growth.
- If compensatory lung growth occurs, how much does it restore/improve lung function??
- If the chest wall's mobility and respiratory muscle dysfunction do not improve, does compensatory lung growth matter??

Strategic Treatment Decisions to Maximize Postnatal Lung Growth

- Improving lung volume early should improve lung growth and development more than late interventions.
- Preventing post-natal pulmonary hypoplasia is likely to improve lung function more than hoping for compensatory growth once it has developed.

Strategies to Promote Lung Function Growth in EOS

- Lung function growth is impaired by progressive EOS.
- Early intervention strategies that increase thoracic volume may improve lung growth but not other lung functions.
- Strategies to maximize thoracic size, chest wall movement, and respiratory muscle function as early as feasible will improve respiratory functional reserve into adulthood.