The Aging Lung

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Is the respiratory system of the elderly different when compared to younger age groups?
Respiratory Changes of Aging

- Physiologic Consequences of Aging cause different manifestations of the same disease
- Co-morbid illness often complicate the clinical picture
- Psychosocial changes of aging cause different challenges for those caring for patients with lung disease
Defining “Normal” in the Elderly Adult is Difficult

• Most elderly are women; studies defining normal have been done on men
• Greater variability in normalcy in elderly than in younger adults.
• Difficult to exclude occult disease, subclinical symptoms, former smokers
• Diabetes, lower extremity edema, hypertension associated with lower lung tests
Respiratory Function in the Elderly

- Decreased Static Elastic Recoil
- Decreased Chest Wall Compliance
- Decreased Strength of Respiratory Muscles
- Impaired Respiratory Reflexes
- Impaired Perception of Respiratory loads
- Near Normal Gas Exchange
Respiratory Function in the Elderly

Changes in Elastic Recoil

• Static elastic recoil pressure decreases and pressure volume curve is shifted to the left.

• No change in total content- elastin and collagen but ratio increased.

• Hypotheses: spatial arrangement and/or cross-linking of elastin fibers network abnormal.
Respiratory Function in the Elderly

Changes in Elastic Recoil

- Elastic fibers degenerate; as a result, airspaces enlarge and small airways tend to collapse

- Dynamic CT scans show air trapping
Respiratory Function in the Elderly
Changes in Elastic Recoil

• BAL studies in elderly (mean age 74 yrs) have shown higher % of neutrophils (40% vs 10%) and lower % of macrophages (32% vs 67%).

• BAL samples show high levels of IL-8, elastase, and other antiproteases.
Respiratory Function in the Elderly

Alterations of Thoracic Cage

- Chest wall compliance decreases with age caused by calcification of other structures (costal cartilage and vertebral articulations calcify; disk spaces narrow)
- Age-related osteoporosis results in partial (wedge) or complete (crush) vertebral fractures

  females 2 X males

  1 in 5 >75 yrs. has normal spine
Loss of Bone Mineral Density with Age

The Radiographic appearance of the Chest in Patients of Advanced Age

• A study of 100 chest radiographs of normal subjects aged 75-93
• 25% had severe kyphosis as a result of vertebral wedge or crush fractures (>50 degrees)
• 43% had moderate kyphosis (35-50 degrees)
• 23% were normal

Edge et al Br J Radiol 1984
80 year old asthmatic woman presents with a 1 year history of progressive shortness of breath. She has had asthma for 10 years and had been stable under the care of her primary care physician on low dose inhaled corticosteroids and occasional beta agonist therapy by metered dose inhaler.
Baseline

2 1/2 years later
Respiratory Function in the Elderly

Changes in Respiratory Muscle function

• The decrease in chest wall compliance and increase in FRC impairs muscle function

• Diaphragm curvature modified because of the kyphotic curvature of the spine and the increase in AP diameter of the chest

• This impairs its force-generating capabilities (max. trans-diaphragmatic pressure reduced by 25%)
Respiratory Function in the Elderly

Changes in Respiratory Muscle Function

- Respiratory muscle strength is related to nutritional status
- Nutritional status often deficient in elderly: causes decrease in MIP, MEP, MVV, hand grip
- Comorbid illnesses (CHF, Parkinson’s, CVA)
- Respiratory muscle function is energy (blood flow) dependent. In CHF, CI correlates with Pdi and ↓ limb strength
Peripheral Muscle Strength Declines with Aging

- Decrease in muscle mass (x-sectional fiber area)
- Decrease in # of fibers (Type II “fast twitch”)
- Alteration in neuromuscular junction
- Loss of peripheral motor neurons & denervation of type II muscle fibers
- Slowing of contraction (↓ maximal shortening velocity) [Ca\(^+\) transport, uncoupling of ATP]
- Decreased synthesis of muscle myosin heavy chain (decreased repair ability)
Physiologic Changes of Aging that Affect Lung Function Tests

1. Loss of height
2. Loss of muscle power
3. Increased stiffness of the chest wall
4. Loss of elastic recoil
Lung Volume Terminology

- Inspiratory reserve volume
- Inspiratory capacity
- Tidal volume
- Expiratory reserve volume
- Vital capacity
- Total lung capacity
- Functional residual capacity
- Residual volume
## Pulmonary Function Changes with Aging - Lung Volumes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital Capacity</td>
<td>Decreased</td>
</tr>
<tr>
<td>Functional Residual Capacity</td>
<td>Increased</td>
</tr>
<tr>
<td>Residual Volume</td>
<td>Increased</td>
</tr>
<tr>
<td>Closing Volume</td>
<td>Increased</td>
</tr>
<tr>
<td>Total Lung Capacity</td>
<td>No Change</td>
</tr>
</tbody>
</table>
Pulmonary Function Changes with Aging- Gas Spirometry

- $\text{FEV}_1$: Decreased
- $\text{FEV}_1/\text{FVC}$: Decreased
- MEFR: Decreased
Pulmonary Function Changes with Aging - Gas Exchange

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change</th>
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</thead>
<tbody>
<tr>
<td>Diffusing Capacity</td>
<td>Decreased</td>
</tr>
<tr>
<td>A-a O₂ Gradient</td>
<td>Decreased</td>
</tr>
<tr>
<td>PaCO₂</td>
<td>No Change</td>
</tr>
</tbody>
</table>
Fall in Lung Function with Age is not Linear

- Fall in FEV$_1$ averages 25-35 ml/year
- Ages 25-39 years = 20 ml/year
- Ages 65 and older = 35 ml/year
77 year old man presents to his doctor with increasing dyspnea for the last 6 months. He is no longer able to play golf and has difficulty shopping and walking up stairs.

His past medical history is negative for serious disease. He is a former smoker of 2 packs of cigarettes a day but stopped 22 years ago.
Normal Spirogram and Spirogram Typical of Patients With Mild to Moderate COPD

<table>
<thead>
<tr>
<th></th>
<th>FEV₁</th>
<th>FVC</th>
<th>FEV₁/FVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>4.15</td>
<td>5.2</td>
<td>80%</td>
</tr>
<tr>
<td>COPD</td>
<td>2.35</td>
<td>3.9</td>
<td>60%</td>
</tr>
</tbody>
</table>

COPD Risk and Smoking Cessation

Never smoked or not susceptible

Smoked and susceptible

Quit Age 45

Age 65

Death

Disability

FEV$_1$ (%)

Age (years)

Changes in Expiratory flow with Aging
The Flow Volume Curve

Normal 70 yr old —— Normal 25 yr old
Effects of Exercise on Hyperinflation

<table>
<thead>
<tr>
<th>Normal</th>
<th>Progression</th>
<th>Static Hyperinflation</th>
<th>Dynamic Hyperinflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC</td>
<td>VT</td>
<td>VT</td>
<td>VT</td>
</tr>
<tr>
<td>TLC</td>
<td>FRC</td>
<td>FRC</td>
<td>FRC</td>
</tr>
<tr>
<td>ERV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
</tr>
</tbody>
</table>

- **Years - Decades**: Progression
- **Rest**: Static Hyperinflation
- **Seconds - Minutes Exercise**: Dynamic Hyperinflation

Air Trapping at Rest
Air Trapping During Exercise
Respiratory Function in the Elderly

Respiratory Reflexes

- Response to isocapnic hypoxia is decreased by 50% compared to young normals
- Hyperoxic hypercapnic response reduced 60%
- Decreased perception of added resistive or elastic loads is diminished
- Central drive (P.1test) is diminished
- Sleep apnea common - up to 44% have AHI > 20
Case History

75 year old asthmatic woman non-smoker who has had 3 admissions to the intensive care unit for severe status asthmaticus. Each time the patient has been found by her family in extremis when they returned home from work.
Perception of Dyspnea in the Elderly

- Decreased perception of elastic and resistive loads
- Perception of bronchoconstriction
Perception of Bronchoconstriction in the Elderly:

Young and old normals and asthmatics

Connolly et al Thorax 47:410, 1992
Dyspnea Awareness Scale
After Induced Bronchoconstriction
Score 1-4

1. No Symptoms
2. Mild discomfort
3. Moderate discomfort
4. Severe; need immediate treatment
## Post Methacholine Dyspnea
**Young vs. Elderly**

<table>
<thead>
<tr>
<th></th>
<th>Fall FEV1</th>
<th>Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>young</td>
<td>13.7%</td>
<td>2.76*</td>
</tr>
<tr>
<td>elderly</td>
<td>16.3%</td>
<td>1.53</td>
</tr>
<tr>
<td><strong>Asthma</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>young</td>
<td>21.5%</td>
<td>3.06**</td>
</tr>
<tr>
<td>elderly</td>
<td>27.4%</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*p=0.004  **p=0.001*
Conclusion:

Elderly normal and asthmatic subjects show reduced subjective awareness of bronchoconstriction compared to young normals and asthmatic patients

Connolly et al Thorax 47:410, 1992
Protective airway reflexes in the elderly

- Aspiration reflex
- Cholinergic bronchoconstriction
- Cough
- Mucociliary clearance
- Beta-adrenergic responsiveness
Case History

80 year old asthmatic complains of recent dyspnea. Shortness of breath occurs at rest and is described as difficulty taking a deep breath and filling up my lungs with air.
Psychosocial Changes of Aging

• 10% of elderly population mentally debilitated
• Depression in the elderly common
• Social and financial stresses high
• Anxiety about dying may be high
• Compliance with medication a problem
Respiratory Diseases of the Elderly are often Undertreated

- Forgetfulness common in the elderly
- Denial of disease or symptoms common
- Decreased perception of symptoms
- Patients assume symptoms due to aging
- Cost of medications may be prohibitive
- Side effects of drugs more common
- Physicians may be cause of under treatment