EMERGING OCCUPATIONAL LUNG DISEASES IN MINERS

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RMAOEM
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Disclosures

- Clarifying Distribution, Trends, and Determinants of Adverse Health in US Miners -- Alpha Foundation for the Improvement of Mine Safety and Health (Co-Investigator)

- Black Lung Clinics Program and Radiation Exposure Screening and Education Program grants -- Health Resources and Services Administration (Principal Investigator)
Objectives

- Describe recent epidemiologic trends in coal mine dust lung disease (CMDLD)
- Describe the broader spectrum of CMDLD
  - Rapidly progressive pneumoconiosis
  - COPD and emphysema from exposure to coal mine dust and silica dust
  - Dust related diffuse fibrosis
  - Silicoproteinosis
  - Lung cancer from respirable silica
  - Simple and complicated CWP
Recent trends in occupational lung disease in U.S. miners are of great concern.

- Doubling of tenure-adjusted radiologic Coal Worker’s Pneumoconiosis (CWP) prevalence from 1990 to 2008 (NIOSH WoRLD Report, 2008)
- Increasing CWP mortality (years of potential life lost) (MMWR 2009)
- Severe CWP cases among young miners who worked exclusively under current dust exposure limits (MMWR 2006)
- Rapidly progressive CWP (Antao et al., 2005)
Percent of miners with Coal Workers’ Pneumoconiosis (CWP) by tenure in mining, 1970-2006

Source: NIOSH Coal Workers’ X-ray Surveillance Program (CWXSP) as cited in NIOSH 2007 WoRLD Report, Figure 2-4.
Rapidly progressive coal workers’ pneumoconiosis in the United States: geographic clustering and other factors

V C dos S Antao, E L Petsonk, L Z Sokolow, A L Wolfe, G A Pinheiro, J M Hale, M D Attfield

*Results from NIOSH Coal Workers’ Health Surveillance Program, 1996-2002. Not shown are counties with fewer than 5 miners evaluated.*
Specific findings of CWP and PMF

- 29,521 miners examined (1996-2002)
  - 886 cases (3%) with CWP
- 783 miners evaluated for progression
  - 277 cases (35.4%) of rapid progression
    - 41 cases of PMF (14.8%)
      - Stage A: 16 cases
      - Stage B: 20 cases
      - Stage C: 5 cases
Possible risk factors for rapidly progressive CWP

- Smaller mine > larger mine
- Longer tenure in jobs at face
- Younger > older
  - Implicating recent mining conditions
- Other factors
  - Mining techniques
  - Approaches to dust control
  - Inadequate enforcement of MSHA PEL
Case 1

- 55 year old underground coal miner from southwestern Virginia
- Worsening symptoms of cough, sputum production, and shortness of breath
- 23 pack-year tobacco smoke exposure
Case 1: Occupational History

- Began work as an underground coal miner in 1980
- Worked mainly as a roof bolter for 23 years until 2003
- Left work due to worsening chest symptoms
Case 1 Diagnosis: Coal Mine Dust Lung Disease

- Rapidly progressive coal worker’s pneumoconiosis with Category C progressive massive fibrosis
- Background of simple pneumoconiosis
Current Concepts: Coal Mine Dust Lung Disease (CMDLD)

- Rapidly Progressive Pneumoconiosis
- **Chronic Obstructive Pulmonary Disease**
  - Emphysema/Chronic Bronchitis
- Dust Related Diffuse Fibrosis (DDF)
- Simple and complicated CWP
- Silicoproteinosis (acute/accelerated)
- Lung cancer (probably due to silica)
Chronic Bronchitis and Coal Dust

- U.S. and British cross sectional studies show relationships between symptoms of cough, sputum, wheezing and breathlessness and:
  - Duration of exposure - years
  - Cumulative exposure to respirable dust
  - Dust exposure and cigarettes contribute independently
- Symptoms of bronchitis correlate with loss of FEV1
- Once symptoms develop, decline in function may continue after exposures ceases.
Coal Mine Dust Emphysema
Autopsy Studies: Emphysema & Coal Dust

- Emphysema is more frequent in miners than non-miners. (*Ryder 1970*)
- Severity of centrilobular emphysema is related to findings of dust in lungs. (*Cockcroft 1982*)
- Amount of dust in lungs correlates with presence of emphysema. (*Ruckley 1984*)
- Extent of emphysema in smoking miners is related to coal dust content of lungs and to smoking. (*Leigh 1982*)
- In lifelong nonsmoking coal miners, extent of emphysema is related to coal dust content and age. (*Leigh 1983, 1994*)
Emphysema and Coal Dust (Kuempel 2009)

- 722 Autopsied Miners from the NCWAS
- Graded emphysema severity
- Cumulative exposure to dust predicted emphysema severity
- Dust exposure and cigarette smoking predicted emphysema similarly
- **Coal Dust, Smoking, Age, and Race** were all significant predictors of emphysema severity
## Emphysema Scores By Smoking & Mining Status

<table>
<thead>
<tr>
<th>Group</th>
<th>Never Smokers</th>
<th>Ever Smokers</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Miners</td>
<td>295 36.4</td>
<td>392 16.3</td>
<td>0.0015</td>
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<tr>
<td>Non-Miner Controls</td>
<td>46 15.5</td>
<td>152 18.4</td>
<td>0.0038</td>
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<tr>
<td>P-Value</td>
<td>0.0001</td>
<td>0.0001</td>
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</table>
Silica and COPD: with & without CXR changes

- Decrement in lung function (FEV1) from respirable silica:
  - Occupational quartz exposure with spirometric airflow limitation in Norwegian men ages 30–46 years (Humerfelt 1998)
  - Swedish granite crushers, excess loss of FEV1 and reduced FEV1/FVC ratio (Malmberg 1993)
  - South African gold miners (Hnizdo 1992)
  - Chronic obstructive pulmonary disease due to occupational exposure to silica dust: a review of epidemiological and pathological evidence (Hnizdo and Vallyathan 2003)

- Obstructive lung function decrements are also seen in concrete workers, diatomaceous earth workers, and pottery workers exposed to silica.
Silicotic nodule with emphysema
Case 2: History

- 57 year old male with progressive SOB, cough, sputum production, and wheezing since 1990. Reports DOE 100 feet and 1 flight of stairs.
- Smoked 1 ppd for 32 years, quit in 2003
- Occupation – school janitor
- Evaluated in 2005 and found to have 2.5X 5.5 polygonal shaped RUL mass.
Case 2: History

- Lives in Indiana on a small farm
- Fixed old tractors and cars for many years
- No pets, does not work in agriculture
- Hobbies: deer hunting and fishing
- Physical Exam: Normal except for mild coarse wheeze on expiration
Case 2: Additional Occupational History

- 13 years of work as a coal miner with 11 years underground in 28” - 46” coal
  - Continuous Miner Operator
  - Drill operator
  - Roof bolter
  - Shuttle car operator and general inside laborer

- Worked in small mines in eastern Kentucky between 1969 and 1988
Pulmonary function testing: spirometry

<table>
<thead>
<tr>
<th>Spirometry</th>
<th>Ref</th>
<th>Pre Meas</th>
<th>Pre % Ref</th>
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</thead>
<tbody>
<tr>
<td>FVC Liters</td>
<td>4.57</td>
<td>4.43</td>
<td>97</td>
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<tr>
<td>FEV1 Liters</td>
<td>3.65</td>
<td>2.92</td>
<td>80</td>
</tr>
<tr>
<td>FEV1/FVC %</td>
<td>80</td>
<td>** 66</td>
<td></td>
</tr>
<tr>
<td>FEV1/SVC %</td>
<td>65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEF25-75% L/sec</td>
<td>3.61</td>
<td>** 1.76</td>
<td>** 49</td>
</tr>
<tr>
<td>PEF L/sec</td>
<td>6.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEF/FIF50</td>
<td>0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FET100% Sec</td>
<td>10.64</td>
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PFTs: Normal lung volumes, low DLCO

<table>
<thead>
<tr>
<th>Lung Volumes:</th>
<th>Ref</th>
<th>Pre Meas</th>
<th>Pre % Ref</th>
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<tbody>
<tr>
<td>VC</td>
<td>Ltrs</td>
<td>4.57</td>
<td>4.49</td>
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<tr>
<td>TLC</td>
<td>Ltrs</td>
<td>6.59</td>
<td>5.95</td>
</tr>
<tr>
<td>RV</td>
<td>Ltrs</td>
<td>2.01</td>
<td>1.45</td>
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<tr>
<td>RV/TLC</td>
<td>%</td>
<td>31</td>
<td>24</td>
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<tr>
<td>FRC PL</td>
<td>Ltrs</td>
<td>3.36</td>
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<tr>
<td>FRC N2</td>
<td>Ltrs</td>
<td>3.36</td>
<td>3.72</td>
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<thead>
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<th>Diffusion</th>
<th>Ref</th>
<th>Pre Meas</th>
<th>Pre % Ref</th>
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<tr>
<td>DLCO</td>
<td>33.8</td>
<td><strong>15.1</strong></td>
<td><strong>45</strong></td>
</tr>
<tr>
<td>DL Adj</td>
<td>33.8</td>
<td><strong>15.4</strong></td>
<td><strong>46</strong></td>
</tr>
<tr>
<td>DLCO/VA</td>
<td>5.24</td>
<td><strong>2.91</strong></td>
<td><strong>56</strong></td>
</tr>
<tr>
<td>DL/VA Adj</td>
<td></td>
<td></td>
<td>2.97</td>
</tr>
<tr>
<td>VA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BHT</td>
<td></td>
<td>10.11</td>
<td></td>
</tr>
<tr>
<td>DLCO ECode</td>
<td></td>
<td>0000</td>
<td></td>
</tr>
<tr>
<td>IVC</td>
<td></td>
<td>4.11</td>
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<tr>
<td>85% Measured VC</td>
<td></td>
<td></td>
<td>3.82</td>
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Exercise physiology

--- EXERCISE TEST SUMMARY RESULTS ---

<table>
<thead>
<tr>
<th>WORK CAPACITY</th>
<th>Base</th>
<th>AT</th>
<th>Peak VO2</th>
<th>Peak VO2</th>
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</thead>
<tbody>
<tr>
<td>VO2 L/min</td>
<td>0.320</td>
<td>1.020</td>
<td>1.858</td>
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<tr>
<td>VO2/kg mL/kg/min</td>
<td>4.0</td>
<td>12.9</td>
<td>23.5</td>
<td>78</td>
</tr>
<tr>
<td>Work Watts</td>
<td>0</td>
<td>62</td>
<td>142</td>
<td>78</td>
</tr>
<tr>
<td>%VO2 @ AT</td>
<td>0</td>
<td>** 41</td>
<td>** 41</td>
<td>78</td>
</tr>
</tbody>
</table>

INDICES OF GAS EXCHANGE

<table>
<thead>
<tr>
<th>Test Level</th>
<th>pH</th>
<th>PaCO2</th>
<th>PaO2</th>
<th>HCO3-</th>
<th>SaO2</th>
<th>SpO2</th>
<th>A-aDO2</th>
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</thead>
<tbody>
<tr>
<td>Base</td>
<td>7.42</td>
<td>36.4</td>
<td>91.8</td>
<td>23.4</td>
<td>91</td>
<td>99</td>
<td>11.7</td>
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<tr>
<td>Peak VO2</td>
<td>7.34</td>
<td>33.9</td>
<td>64.2</td>
<td>17.9</td>
<td>87</td>
<td>91</td>
<td>50.5</td>
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</table>
Dust Related Diffuse Fibrosis (DDF)
Case 2 Diagnosis:
Coal Mine Dust Lung Disease

- Emphysema due to coal mine dust
- Dust - Related Diffuse Fibrosis (DDF)
Dust Related Diffuse Fibrosis (DDF)

- Disease often confused with Idiopathic Pulmonary Fibrosis (IPF)
- Cannot be idiopathic when there is significant exposure to mineral dust
- Irregular opacities on CXR with decreased diffusion capacity on lung function and restrictive impairment
- Bridging fibrosis connecting macular, nodular, or PMF lesions
- Pigmented interlobular septal thickening
Histology of DDF

- Interstitial fibrosis resembling UIP
- Micro and macro nodules
IPF (Idiopathic Pulmonary Fibrosis)

By international consensus\(^1\) the diagnosis of IPF requires

- ‘Exclusion of other known causes of ILD (e.g., domestic and occupational/environmental exposures, connective tissue disease, and drug toxicity).’

- There is no basis for this diagnosis in a patient with substantial occupational exposure to fibrogenic dust.

Dust Related Diffuse Fibrosis

- Welsh coal miners with DDF presented at younger ages and lived longer (McConnochie, Annals Occup Hyg, 1988)
  - Age 55.5 ± 7 years
  - Survival 11.4 ± 5 years
  - DDF was present in 15 - 20% of miners’ lungs in autopsy series
  - Much greater than IPF in the general population

- Several other articles have described clinical findings typical for IPF in mining populations. (Monso, Arch Environ Health 1990; Brichet, Rev Mal Respir 1997)
Classical Teaching: Coal Workers’ Lung Diseases

- Simple Pneumoconiosis: small scars < 10 mm
- Progressive Massive Fibrosis > 10 mm lesions
- Workers exposed to mixed dust may get silicosis or mixed-dust pneumoconiosis
- Caplan’s Syndrome – Rheumatoid Pneumoconiosis
Coal Workers’ Pneumoconiosis (CWP)

Progressive massive fibrosis
Complicated pneumoconiosis

Source: NIOSH Coal Workers’ X-ray Surveillance Program (CWXSP)
Concise Clinical Review

Coal Mine Dust Lung Disease
New Lessons from an Old Exposure

Edward L. Petsonk1, Cecile Rose2,3, and Robert Cohen4

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Questions?