Occupational COPD

Susan M Tarlo, MB BS FRCP(C)
Toronto Western and St Michael’s Hospital,
University of Toronto, Dept Med and Dalla Lana School of Public Health
Issues to consider

• Definition: epidemiologic vs case definition
• Causes
• Confounding factors: smoking, others
• Diagnosis
• Surveillance issues
• Specific risk populations (e.g., flavour/fragrance, aluminum smelters, hog farmers and other farmers, welders, miners)
Definition of COPD

- COPD = chronic obstructive pulmonary disease

= a PFT diagnosis (from spirometry)
  - not synonymous with chronic bronchitis (defined as chronic cough and sputum)
  - not synonymous with emphysema

But often co-exists with chronic bronchitis and/or emphysema
COPD is not a single disease: “other” chronic obstructive lung diseases can co-exist or overlap

- Asthma – may result in a component of irreversible airflow limitation (COPD)
- Chronic bronchiolitis – e.g. from nitrogen oxides, sulphur dioxide or from popcorn butter flavoring (smoking-related airway disease usually starts in bronchioles)
- Bronchiectasis

Studies of COPD usually aim to exclude other airway diseases
Importance

- COPD affects >5% of the population and is associated with high morbidity and mortality
- It is 3rd ranked cause of death in US with >120,000 deaths/y
A clinical diagnosis of COPD should be considered in any patient who has dyspnea, chronic cough or sputum production, and a history of exposure to risk factors for the disease.

Spirometry is *required* to make the diagnosis; the presence of a post-bronchodilator FEV$_1$/FVC < 0.70 confirms the presence of persistent airflow limitation and thus of COPD.
Criteria for COPD

• GOLD criteria (since 2001) of FEV1/FVC ≤70%
  – Widely used but widely criticized in correspondence (e.g. Enright, Thorax ’07, Enright, Thorax ‘09, “GOLD Stage 1 is crying wolf”) since FEV1/FVC ratio varies with age: taking a fixed ratio will overestimate disease, e.g., in men >40y (by~16%) and underestimate in younger individuals (by~13%)

• ATS/ERS criteria (Eur Respir J 2005;26:319-338) are to use the LLN of the FEV1/FVC ratio (based on age, sex and height) as the cutoff for normal
Assessment of Airflow Limitation: Spirometry

- Spirometry should be performed after the administration of an adequate dose of a short-acting inhaled bronchodilator to minimize variability.

- A post-bronchodilator FEV$_1$/FVC < 0.70 confirms the presence of airflow limitation.

- Where possible, values should be compared to age-related normal values to avoid overdiagnosis of COPD in the elderly.
Global Strategy for Diagnosis, Management and Prevention of COPD

Classification of Severity of Airflow Limitation in COPD*

In patients with $\text{FEV}_1/\text{FVC} < 0.70$:

**GOLD 1: Mild**  \hspace{1cm} $\text{FEV}_1 \geq 80\%$ predicted

**GOLD 2: Moderate**  \hspace{1cm} $50\% \leq \text{FEV}_1 < 80\%$ predicted

**GOLD 3: Severe**  \hspace{1cm} $30\% \leq \text{FEV}_1 < 50\%$ predicted

**GOLD 4: Very Severe**  \hspace{1cm} $\text{FEV}_1 < 30\%$ predicted

*Based on Post-Bronchodilator $\text{FEV}_1$*
Assessment of COPD

- Assess symptoms
- Assess degree of airflow limitation using spirometry
- Assess risk of exacerbations

Use history of exacerbations and spirometry. Two exacerbations or more within the last year or an FEV₁ < 50% of predicted value are indicators of high risk.
Risk Factors for COPD

Genes

Exposure to particles
- Tobacco smoke
- Occupational dusts, organic and inorganic
- Indoor air pollution from heating and cooking with biomass in poorly ventilated dwellings
- Outdoor air pollution

Lung growth and development
- Gender
- Age
- Respiratory infections
- Socioeconomic status
- Asthma/Bronchial hyperreactivity
- Chronic Bronchitis
Occupational COPD

• COPD caused in whole or in part by occupational exposures
The leading risk factor for COPD is smoking

- Smoking accounts for 80% of all COPD
- Smoking is falling, (17% in Canada in 2010, down from 25% in 1999 [Health Canada website 2011]) but has been common in working populations, especially current or ex-smoking in older workers
- Therefore estimates of COPD related to work must consider smoking as a confounder as well as a possible co-factor
American Thoracic Society Documents

American Thoracic Society Statement: Occupational Contribution to the Burden of Airway Disease

This Official Statement of the American Thoracic Society was approved by the ATS Board of Directors June 2002.
ATS Statement

• Published in 2003; data through 1999
• Reviewed occupational links to asthma and to COPD
• Concentrated on population attributable risk (PAR) %
• Work hazard defined broadly - typically: “exposure to vapors, gas, dust, and fumes”
• Assessed risks of chronic cough and sputum, exertional dyspnoea and COPD
ATS Statement: COPD airflow limitation (PFT Deficit)

- 6 epidemiological studies reviewed including > 12,000 subjects


- PAR% for occupational dust/fume: Range = 12-55%, Median = 18%
ATS Statement: Conclusion

‘ .......a value of 15% is a reasonable estimate of the occupational contribution to the population of the burden of COPD. ’

Blanc & Torén, Int J Tuberc Lung Dis (IJTLD) 2007; 11:122-33

• Systematic review

• Medline search with cross check of citations

• Studies published since the ATS review
Airflow Limitation (PFT Deficit)

- 6 studies including > 18,000 subjects; 1 mortality study >300,000 subjects
- Sweden (2), USA (2), Spain, Australia, International (13 countries);
- PAR% for occupational exposure: Range = 0-37%, Median = 15%
- PAR% Non-smokers (5 estimates) Range =27-53%, Median = 31%
Data from the FLOW study (1202 subjects with COPD, 742 with BOLD Stage II or more)

- 302 controls matched for age, sex, race
- Evaluated with smoking and other history, spirometry and occupational questions: VGDF (on the longest held job) and job (linked to JEM)
Smoking-Occupational Vapors Gas Dust or Fume (VGDF) Effects


<table>
<thead>
<tr>
<th>Cigarette/Work VGDF Exposure</th>
<th>Subject n</th>
<th>Probability COPD</th>
<th>Excess Prob.</th>
<th>Adjusted OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never/No</td>
<td>178</td>
<td>0.44</td>
<td>0</td>
<td>1.0 (REF)</td>
</tr>
<tr>
<td>Never/Yes</td>
<td>145</td>
<td>0.60</td>
<td>0.16</td>
<td>2.0 (1.3-3.1)</td>
</tr>
<tr>
<td>Ever/No</td>
<td>512</td>
<td>0.83</td>
<td>0.40</td>
<td>6.7 (4.6-9.8)</td>
</tr>
<tr>
<td>Ever/Yes</td>
<td>669</td>
<td>0.91</td>
<td>0.47</td>
<td>14.1 (9.3-21)</td>
</tr>
</tbody>
</table>
Risk of COPD (cases v. referent) by exposure group and smoking status

*Blanc et al. J Occup Environ Med 2009 51:804-10*

- Adults age 55-75 with self-reported doctor-diagnosed COPD, emphysema or chronic bronchitis recruited by random-digit dialing, + same age-range controls
- Evaluated with smoking and other history, spirometry and occupational questions: VGDF and job (linked to JEM)
Risk of COPD (cases v. referent) by exposure group and smoking status

*Blanc et al. J Occup Environ Med 2009 51:804-10*

<table>
<thead>
<tr>
<th>Risk Group</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No smoking up to 10 pack-years and no occupational exposure</td>
<td>1.0 (Referent)</td>
</tr>
<tr>
<td>No or minimal smoking; occupational exposure</td>
<td>2.0 (0.9-4.6)</td>
</tr>
<tr>
<td>Smoking &gt;10 pack years; No occupational exposure</td>
<td>3.7 (1.9-7.1)</td>
</tr>
<tr>
<td>Smoking and occupational exposure</td>
<td>5.9 (2.9-12.0)</td>
</tr>
</tbody>
</table>

Risk of COPD by Spirometry (FEV$_1$/FVC <0.70) among 98 cases and 1652 Referents
COPD among residents of an historically industrialised area

*Darby et al; Thorax (2012)*

<table>
<thead>
<tr>
<th>Cigarette/VGDF Exposure</th>
<th>Subject n (1183)</th>
<th>Probability COPD</th>
<th>Excess Prob.</th>
<th>Adjusted OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never/No</td>
<td>530</td>
<td>0.02</td>
<td>0</td>
<td>1.0 (REF)</td>
</tr>
<tr>
<td>Never/Yes</td>
<td>302</td>
<td>0.08</td>
<td>0.06</td>
<td>5.6 (2.6-12)</td>
</tr>
<tr>
<td>Low/No</td>
<td>248</td>
<td>0.07</td>
<td>0.05</td>
<td>4.0 (1.8-8.9)</td>
</tr>
<tr>
<td>Low/Yes</td>
<td>279</td>
<td>0.18</td>
<td>0.16</td>
<td>15.7 (7.6-32)</td>
</tr>
<tr>
<td>High/No</td>
<td>186</td>
<td>0.15</td>
<td>0.13</td>
<td>10.4 (4.9-22)</td>
</tr>
<tr>
<td>High/Yes</td>
<td>338</td>
<td>0.31</td>
<td>0.29</td>
<td>32 (16-64)</td>
</tr>
</tbody>
</table>

Low = 20 Pack-years or less; High=>20 Pack-years; VGDF=Vapors, Gas, Dust, or Fumes by Job Exposure Matrix
Summary of Data

- Multiple studies, worldwide, various methods: occupation → COPD, chronic bronchitis

- Both COPD and chronic bronchitis: PAR% estimates yield a median value ~ 15%

- COPD among non-smokers (n=5 values): PAR% = 27%, 30%, 31%, 42%, 43%, 53%
Implications of epi studies

- The occupational contribution to COPD is especially high among non-smokers.
- However, greatest risks of COPD are seen among smokers with occupational exposures to VGDF.
Other interacting factors

• Alpha-one antitrypsin deficiency
• Other genetic factors poorly identified to-date
• ? Confounding and/or interactions with other risk factors such as non-occupational second-hand smoke, biomass fuel exposure, and air pollution
Case example

- Mr MB, age 55
- Smoked 2-3 per day x20y, quit 2004
- Worked x 23 years with TTC as a welder in tunnels, exposed to dusts, including asbestos and welding and diesel fumes (included stainless steel welding and manganese), mostly arc welding
- Progressive SOBOE x2y, now climbing 10 steps
- Cough and clear sputum at work
Case contd

- FEV1 47%, FEV1/VC 40%, FEV1 ↑ 14% (>200ml) post-bd
- Moderate hyperinflation, severe gas trapping, normal DLCO
- Allergy skin tests all negative, including Ni, Chr
- Serial PEFRs 320-360, higher range after prn bd
- CT chest mosaic attenuation, bronchial wall thickening, mucus plugs – no Asb changes
Example of mosaic attenuation in bronchiolitis (exp image)
Case continued

- Δ Occ COPD with asthmatic component and likely component of bronchiolitis
- Changed work to outdoor delivery for TTC
- Combination LABA and inhaled steroid + tiotropium + SABA
- Follow-up FEV1 58%, FEV1/FVC 46%, no further bd response
- Symptomatically improved with outdoor work
- WSIB claim accepted for occ COPD
Occupations with increased risk airflow obstruction (Hnizdo et al, AJIM ’04)

• From NHANES III data, population aged 30-75
• Defined obstruction as FEV1/FVC <75% and FEV1 <80% predicted
• Most frequent associated industries: armed forces; rubber, plastics, and leather manufacturing; utilities; textile mill manufacturing; health care; food products manufacturing; sales; construction; and agriculture
Examples of higher risk occupations for chronic obstructive airways diseases (excluding asthma)

- Hog/poultry farmers
- Cotton and textile workers (byssinosis)
- Welders
- Flavoring workers
- Aluminum pot-workers
- Miners
- WTC dust,
- Deployed military workers in Asia
- Organic dust, gases
- Dust, endotoxin
- Nitrogen oxides, ozone
- Diacetyl (popcorn)
- Al fluorides
- Silica dust
- High pH Calcium oxide dust
- Gases from burn pits, dusts
Occupational diagnostic issues: medical surveillance

- Has been performed for flavoring workers, miners, and some other higher-risk settings
- Spirometry needs: quality tests, preferably with pre-placement baseline values and longitudinal comparisons
- Need to recognize that baseline values in workers are often “supernormal” and a fall to “normal” values may be a significant change
Spirometry surveillance issues

- Need accurate measures of height and weight and appropriate reference values for the workers being tested
- Standing values are slightly higher than sitting – need consistency in posture, and need to consider weight changes and co-morbidities (smoking, recent URI etc.)
- Need appropriate training for staff performing tests outside a hospital lab, e.g. in an occupational setting
Appropriate reference values

- Reference values based on age, sex, height, and preferably would be from those of similar ethnic background living in the same geographic region.
- Canadian reference values are not adjusted for ethnic background – these may overestimate volumes for workers of some ethnic background (NHANES has reference values for some N Am ethnic groups).
- Recent “global” values suggested (Quanjer ‘12).
Cross-sectional and longitudinal abnormalities

- Criteria need to be present for “action levels” i.e. for referral to physician to determine safety to continue work
- ATS/ERS has recommended use of LLN from appropriate reference values for cross-sectional spirometry
- ATS/ERS (2005) for longitudinal changes recommended 15% above the expected decline with age – depending on risk level smaller changes may need physician assessment.
Computerized programs for longitudinal changes

- NIOSH has a computerized program (Spirola) freely available from website
- It can be used to plot individual and group changes and can determine the program’s (technical) variance that for a quality program can allow smaller changes to be identified after several years of data (5-8y)
- Typical decline in healthy non-smokers is ~29ml/y, declines ~50-90ml/y have been associated with morbidity and mortality
Spirola program, CDC NIOSH
www.cdc.gov/niosh/topics/spirometry/spirola.html
Charts for FEV1, FVC, percent predicted values, and summary report for an individual evaluation displayed together.

**Longitudinal FEV1 Evaluation**

- FEV1 (mL) vs. Age (years)
- Rate of FEV1 decline (mL/yr)

**Longitudinal FVC Evaluation**

- FVC (mL) vs. Age (years)

**Longitudinal Percent Predicted and Ratio Evaluation**

- Percentage vs. Age (years)

**Results of analysis:**
- **Last observation:** FEV1 below LLDr
- **Rate of FEV1 decline:** Overall: 141 mL/year, 95% CI (100, 181)
- **Within-person variation:** 76 mL, within the normal range of 250 mL
- **Program variation:** 193 mL, excessive (>180 mL)

**Years of follow-up:** 4 years and 5 months

**Interpretation and suggested actions:**
- Examine the quality of baseline and current test. If confirmed that FEV1 < LLDr, the rate of decline may be excessive.
- Examine the spirometry quality and retest to confirm the results.
Longitudinal FEV1 values (green dots) plotted against age and evaluated against the limit of longitudinal decline (blue line) and the cross-sectional limits: lower limit of normal (purple line) and 0.1th percentile (orange line)
From four years of follow-up the FEV1 chart shows the linear regression line (green line) and monitors the rate of FEV1 decline (right vertical axis). Begin with eight years of follow-up, the interpretation is based on the projected age at which the person may develop moderate lung function impairment.
When is this compensable?

- depends on the workers’ compensation system
- criteria are not published
- relies on “greater or equal probability” of being work-related
- Recognizes partial contribution from smoking etc
- For particular exposures, decisions will likely consider extent of exposures (years x levels), and
- epi studies for particular jobs such as welding + smoking pack years
Prevention

- Smoking cessation
- Prevention of exposures – avoidance of high-risk agents (diacetyl), good ventilation, RPDs (fit tested), worker-education
- Medical surveillance and removal when indicated
- Tertiary measures: pharmacological and general management of COPD