PFTs: Getting the Right Diagnosis

Mary Hart, MSHCS, RRT, AE-C, FAARC
University of Texas Health Science Center of San Antonio
COI

Speaker’s Bureau for Monaghan Medical Corporation

This presentation is sponsored by Monaghan Medical Corporation
Mary’s PFT Journey

Make Every Breath Count

1970

1970
Objectives

- Tom Petty – the Rock Star
- Spirometry in physician offices
- COPD and Asthma Guidelines – lung function testing
- Bronchoprovocation – methods used today
- Getting the right diagnosis
- RTs add value to physician office
COPD

- The face of COPD has changed
- Is now the 3\textsuperscript{rd} leading cause of death in the US
- Early detection can help slow the progress and improve QOL
- GOLD - COPD is a clinical diagnosis that should be based on careful history taking, presence of symptoms and assessment of airway obstruction
Tom Petty – Rock Star
Some of you knew him as.....
Tom L Petty MD – Rock Star

- Dr Thomas L. Petty – Renowned Pulmonologist
- born on Christmas Eve 1932 – CO
- passed away at age 76 - Dec 12, 2009
- Grandmother - TB
- CV – 54 pages in 2009
- First to puncture an artery – ABGs
- First to describe ARDS - 1967
- Portable oxygen cylinders – NASA 1963
- “Father of Home Oxygen” – improved QOL in patients with lung disease
Thomas L Petty – Rock Star MD

- Focused on a broad range of lung disease with common themes: COPD, ARDS, lung CA

- Paved the way for patients to benefit from services that are common today
  - Pulmonary Rehab, Spirometry, Oxygen Management, Medical technology

- Frontline – advice books for Patients, Clinicians

- “Adventures of an Oxy-Phile$_2$” FREE DOWNLOAD
  - www.drtompetty.org

- “Thomas L. Petty Moving Mountains Lung Health Conference” patients, families, providers, caregivers
  - Conference held in the Fall in Colorado

- Thomas L. Petty Aspen Lung Conference - Colorado
Tom Petty – Rock Star MD

Founder of the National Lung Health Education Program (NLHEP), founded in 1997

- Early detection of lung disease – COPD
- Clinical Expertise: Simple Office Spirometry
- “Test your lungs – Know your Numbers”
- www.nlhep.org
Spirometry – common problems

- Inadequate or incomplete inhalation
- Lack of blast effort during exhalation
- Delayed onset of effort
- Incomplete emptying of lungs – COPD may take up to 15 sec
- Additional breath during maneuver
- Lips not tight around mouthpiece

- A slow start to blow
- Exhaling in part through nose
- Coughing, glottic closure
- Obstruction of mouthpiece by teeth or tongue
- Poor posture
- Poor operator knowledge/training
- Poorly maintained equipment/calibration
Steps to instruct patient – Spirometry

- Sit up straight – airway open
- Breathe in fully
- Seal lips and teeth tightly around the mouthpiece
- Blast the air out as fast and as long as possible until the lungs are completely empty
- Breathe in fully again without removing the mouthpiece from the mouth
- Repeat test until three acceptable and reproducible results/tests are obtained – up to 8 attempts
- The highest FEV1 and FVC should be reported even if they are from separate efforts.
- Nose clips should be used on all patients
What do you think?
COPD Guidelines

- 1st GOLD Guidelines – 1998
- GOLD Guidelines for COPD
  Feb 2013 latest edition

- Spirometry for Health Care Providers
  Encourage use of Spirometry in PCP office
  Understand the importance of spirometry in management of COPD
  Provide information on how to perform spirometry correctly
  Explain interpretation of results
Table 2. Physician scores on COPD knowledge by level of training

<table>
<thead>
<tr>
<th>Physician factors</th>
<th>Pathogenesis/physiology</th>
<th>Assessment and diagnosis</th>
<th>Principle of therapy</th>
<th>Pharmacology</th>
<th>Other modalities</th>
<th>Prevention</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of questions per section</td>
<td>8</td>
<td>8</td>
<td>4</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>Total mean score expressed in %</td>
<td>66.00±19.00</td>
<td>53.0±14.30</td>
<td>62.00±29.00</td>
<td>59.00±20.00</td>
<td>52.00±24.83</td>
<td>89.00±28.90</td>
<td>59.00±12.86</td>
</tr>
<tr>
<td>Total mean score</td>
<td>5.27±1.49</td>
<td>4.21±1.42</td>
<td>2.46±1.18</td>
<td>5.89±2.08</td>
<td>3.09±1.50</td>
<td>1.78±0.58</td>
<td>22.37±0.39</td>
</tr>
<tr>
<td>Medical officers</td>
<td>4.40±1.56</td>
<td>3.76±1.49</td>
<td>2.04±1.23</td>
<td>5.12±2.21</td>
<td>3.06±1.51</td>
<td>1.73±0.69</td>
<td>19.93±4.98</td>
</tr>
<tr>
<td>Residents in FM</td>
<td>5.31±1.01</td>
<td>4.38±1.26</td>
<td>2.63±0.72</td>
<td>6.00±1.71</td>
<td>2.75±1.34</td>
<td>1.63±0.50</td>
<td>22.25±2.67</td>
</tr>
<tr>
<td>Residents in IM</td>
<td>5.63±1.32</td>
<td>4.28±1.39</td>
<td>2.65±1.18</td>
<td>6.08±1.91</td>
<td>3.06±1.47</td>
<td>1.80±0.58</td>
<td>23.10±4.32</td>
</tr>
<tr>
<td>Specialists (FM)</td>
<td>5.00±0.00</td>
<td>5.50±0.58</td>
<td>1.50±0.58</td>
<td>6.00±2.31</td>
<td>2.50±1.73</td>
<td>2.00±0.00</td>
<td>22.50±1.73</td>
</tr>
<tr>
<td>Specialists (IM)</td>
<td>6.50±0.58</td>
<td>4.50±0.58</td>
<td>3.00±0.00</td>
<td>8.00±0.00</td>
<td>4.50±0.58</td>
<td>2.00±0.00</td>
<td>28.50±0.58</td>
</tr>
<tr>
<td>Specialists (Pulm)</td>
<td>8.00±0.00</td>
<td>7.00±0.00</td>
<td>4.00±0.00</td>
<td>10.00±0.00</td>
<td>6.00±0.00</td>
<td>2.00±0.00</td>
<td>37.00±0.00</td>
</tr>
<tr>
<td>p values</td>
<td>&lt;0.001</td>
<td>0.005</td>
<td>0.008</td>
<td>0.001</td>
<td>0.025</td>
<td>0.704</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Total number of physicians = 156. COPD = chronic obstructive pulmonary disease, FM = family medicine, IM = internal medicine, Pulm = pulmonologist.

Table 3. Physician practice and adherence to COPD guideline

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>N=50</th>
<th>Implementation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spirometry performed</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Assessment of severity</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Smoking cessation modalities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brief intervention</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>Nicotine replacement therapy</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Medications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral short-acting β agonist</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>Oral aminophylline</td>
<td>29</td>
<td>58</td>
</tr>
<tr>
<td>Inhaled corticosteroids</td>
<td>36</td>
<td>72</td>
</tr>
<tr>
<td>Inhaled long-acting β agonist</td>
<td>36</td>
<td>72</td>
</tr>
<tr>
<td>Vaccinations</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pulmonary rehabilitation</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Inhaled corticosteroids as a fixed dose combination with inhaled long-acting β2 agonist.

COPD = chronic obstructive pulmonary disease.

Figure 1. Barriers to COPD guideline

- Lack of familiarity: 39.8%
- Lack of awareness: 23.1%
- Lack of time: 19.2%
- Disagree with recommendation: 14.1%
- Others: 7.8%
Physician Adherence to Guidelines

- International Journal of COPD March 2011
  *Barriers to Adherence to Chronic Obstructive Pulmonary Disease Guidelines by Primary Care Physicians*

**PCP = 309  IM = 191**

- PCP 28%  IM 36%  Familiar with GOLD
- PCP 24%  IM 23%  order spirometry when pt reports symptoms that lead you to expect COPD
- PCP 69%  IM 70%  believe COPD should be confirmed with spirometry
- PCP 24%  IM 29%  order inhaled LABA with COPD/dyspnea
- PCP 80%  IM 76%  agree that inhaled LABA should be added to therapy for pts whose dyspnea with daily activities not relieved with SABA
Barriers – Adherence to GOLD

- Lack of a “working spirometer”
- #1 barrier-Inadequate confidence in interpreting spirometry
Asthma

- 11 People die from asthma each day
- Is the leading cause of chronic illness in children
- Asthma can not be cured but it can be managed
- Is one of the leading readmissions to hospitals today
- National Asthma Education and Prevention Program – NIH NHLBI EPR 3 asthma guidelines

Sam Linton 11, died of asthma at school when a teacher was too busy to call an ambulance. He lay coughing and gasping for breath in the school corridor.
Case Study – Is it Asthma?
30 y/o housewife referred by her allergist for refractory symptoms of asthma, unresponsive to high dose ICS, long acting beta agonists, leukotriene modifiers and immunotherapy. Wheezing and exertional shortness of breath has progressed over the last few years.

Of course she has asthma!
Is it really asthma?

<table>
<thead>
<tr>
<th>30 Year Old Female with Allergies and Wheeze</th>
<th>% Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC</td>
<td>74%</td>
</tr>
<tr>
<td>FEV₁</td>
<td>38%</td>
</tr>
<tr>
<td>FEV₁ / FVC</td>
<td>42%</td>
</tr>
</tbody>
</table>
Is it really asthma? This is why flow volume loops are so important!

![FVC Flow vs. Volume Diagram](image)
Is it really asthma?
Sub-glottic stenosis.....
Case Study – Is it Asthma?
66 y/o female with positive bronchodilator response, steroid dependent and with multiple exacerbations.
Normal spirometry with patient still having symptoms of cough, wheeze and dyspnea on exertion.

<table>
<thead>
<tr>
<th>Pre-BD Results</th>
<th>Pred</th>
<th>Best</th>
<th>%Prd</th>
<th>2nd Best</th>
<th>%Prd</th>
<th>3rd Best</th>
<th>%Prd</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>2.38</td>
<td>2.11</td>
<td>89%</td>
<td>2.00</td>
<td>84%</td>
<td>1.97</td>
<td>83%</td>
<td>2.30</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>1.85</td>
<td>1.60</td>
<td>86%</td>
<td>1.60</td>
<td>86%</td>
<td>1.49</td>
<td>80%</td>
<td>1.85</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>0.78</td>
<td>0.76</td>
<td>97%</td>
<td>0.80</td>
<td>86%</td>
<td>0.76</td>
<td>80%</td>
<td>0.80</td>
</tr>
<tr>
<td>FEF25-75% (L/s)</td>
<td>1.77</td>
<td>1.22</td>
<td>69%</td>
<td>1.54</td>
<td>87%</td>
<td>1.18</td>
<td>66%</td>
<td>1.88</td>
</tr>
<tr>
<td>PEFR (L/s)</td>
<td>5.01</td>
<td>5.23</td>
<td>104%</td>
<td>6.51</td>
<td>130%</td>
<td>4.23</td>
<td>84%</td>
<td>7.62</td>
</tr>
<tr>
<td>Vext (%)</td>
<td>--</td>
<td>4.28</td>
<td>--</td>
<td>3.70</td>
<td>--</td>
<td>3.46</td>
<td>--</td>
<td>3.37</td>
</tr>
<tr>
<td>FIF50/FEF50</td>
<td>--</td>
<td>1.70</td>
<td>--</td>
<td>1.57</td>
<td>--</td>
<td>1.77</td>
<td>--</td>
<td>1.32</td>
</tr>
</tbody>
</table>

Quality Cautions:
(Key: C=Cough, T=Exp Time, E=End Exp, S=Start of Expiration - back extrapolation)

Test comments (Pre):
Site: KoKo988771

Pneumotach calibration date/time: 5/8/2013 07:16 AM
Chest CT shows bilateral ground glass infiltrates-hypersensitivity pneumonitis, chronic eosinophillic pneumonia, Churg-Strauss Syndrome. Pt needs a VATS (video assisted thoracic surgery) – biopsy
Unless spirometry were done, the assumption would still be “asthma”....
Case Study 38 yo Asthma

- 38 yo female diagnosed with asthma at age 20
- DOE, chest tightness, cough to strong odors
- Some improvement with albuterol
- Greater improvement with prednisone
- Takes Fluticasone/Salmeterol 500/50 BID, albuterol 6/day
- 1-2 ED visits/asthma/month – prescribed prednisone/7 days with each visit
- Denies tobacco, ETOH, illicit drugs
- Unemployed
- Sister and Aunt have asthma
Case study – 38 yo Female/Asthma

- Physical exam:
  285#, 5ft 6 in, BP 135/85, HR 92, RR 20, T 98.4
- Neck normal – no stridor
- Chest clear
- Most Everything normal
Case Study 38 yo Asthma

- Diagnosis of asthma based upon symptoms
- Could be wrong: GERD, deconditioning, VCD, CHF, PE, sarcoid, IPF, hyperventilation
- Response to treatment misleading
- Cost/side effects from treatment – need objective confirmation
- May miss life-threatening condition that resembles asthma
How to confirm asthma diagnosis – Bronchoprovocation?

Indications for testing

- Normal PFTs – atypical symptoms
- Normal PFTs and suspicion of diagnosis other than asthma
- Olympic athletes to obtain approval for use of asthma meds
- Suspicion of Occupational asthma
- Research studies
Contraindications

Absolute
• FEV1 < 50% pred.
• MI or stroke in last 3 months
• Uncontrolled hypertension >200/100
• Known aortic aneurysm

Relative
• FEV1 >60 -70%
• Inability to perform spirometry
• Pregnancy
• Nursing Mothers
Prep for Testing: Holding Medications

- 8 hrs – albuterol/Cromolyn
- 24 hrs – Ipratropium, Montelukast
- 48 hrs - salmeterol, formoterol, theophylline
- 72 hrs - all antihistamines
- 1 wk - tiotropium
- 2-3 wks – ICS, oral steroids
- False (-) if continued on medications
Choice of Agents

- Methacholine – causes bronchoconstriction directly stimulation of smooth muscle receptors
  - Very sensitive
  - Rule Out asthma
- Age 6 and up – both Methacholine and Mannitol

- Mannitol – increases osmolality of the airway surface, releasing mast cell mediators causing bronchoconstriction indirectly through intermediate pathways releasing inflammatory mediators
- More specific, make diagnosis of asthma
Methacholine Challenge Testing

- Acceptable spirometer - >70% pred.
- Normal Saline control neb
- 5 step method or 2 minute method 0.0625-16mg/ml
- Stop when best effort FEV1 or FVC drops by >20%, cal. PC 20
- Albuterol neb until FEV1 returns to baseline
- PC 20 <8mg/ml is positive, PC 20 >16mg/ml is negative
- Good Safety Data – no late phase response, good response to albuterol
- Need negative pressure room for testing
How is methacholine delivered

1999 ATS guidelines

English Wrights – 2 min breathing
   Devilbiss 646 – 5 breath dosimeter

Obsolete and difficult to purchase

Study using Aeroeclipse II
Technicians with asthma are at increased risk of bronchospasm during testing and should take extra precautions to minimize their exposure to aerosolized methacholine. Performing methacholine challenge tests on technicians who will be testing patients may be a useful precaution. Knowing that a technician reacts to methacholine could lead a supervisor to reassign technicians or take additional precautions to minimize their exposure to methacholine.

**Rationale.**

In a survey of 600 allergy specialists, about 20% reported symptoms among staff who performed methacholine challenge tests (3). Two cases of asthma have been reported in nurses who frequently administered methacholine challenge tests over a period of more than 2 yr (44). Technicians with known active asthma should not perform methacholine challenges unless appropriate methods are used to avoid exposure to methacholine. They were asymptomatic when leaving the clinic, and only 3 of 1,000 reported symptoms, such as chest soreness, in the days after the test (28). Fewer than 20% of 700 subjects undergoing histamine challenge testing in an occupational setting noted cough, chest tightness, or flushing (41).

### E. Patient Preparation

#### 1. Preparation when scheduling.

When tests are scheduled, patients should be given a list of items/medications to avoid before the test. Table 2 (45–62) lists medications that can decrease airway responsiveness and the time period for which each should be withheld before the test. The goal is to withhold the medication for its biological duration of action (for 90% of patients taking the usual dose). Table 3 lists factors that may increase airway responsiveness.

#### 2. Preparation at testing.

- **a.** Explain the test to the patient. Patients should be told they may experience some minor symptoms, such as cough or chest tightness, but that most patients have no symptoms. They should be warned that occasional severe symptoms may occur. Care should be taken to ensure that the test description does not bias the result. For example, avoid stating that the test induces an asthma attack.
- **b.** Ask the patient if they would like to urinate before the test (stress incontinence could be precipitated, especially in older women). Some hospitals require informed consent for the test (an example of an informed consent document is presented in **Appendix A**).
- **c.** Evaluate the patient for contraindications and review medication use. A pretest questionnaire is useful for this purpose (**Appendix B**).

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**Figure 1.** Schematic diagram illustrating typical nebulizer configurations for both the 2-min tidal breathing protocol (A, an English Wright nebulizer) and the five-breath dosimeter protocol (B, a DeVilbiss model 646 nebulizer). Both include an exhalation filter. Other models of nebulizers may be substituted (see Section II, H).
Current ATS Guideline for 5-Breath Dosimeter Method

- Alternate option for Methacholine Challenges
- Delivery of 9 μL (±10%) per 0.6 s inhalation
- Nebulizer is attached to dosimeter that delivers aerosol for 0.6 s during inhalation from the nebulizer
- Patients are instructed to inhale slowly for 5 seconds, breath hold 5 seconds, exhale 5 seconds x 5 cycles
- Named Nebulizer: Devilbiss 646 Nebulizer
  - MMAD unknown, 70% of aerosol is < 5.0 μm
  - Product has been discontinued by the manufacturer (Sunrise Medical)
Current ATS Guideline for 2-Minute Tidal Breathing Method

- Method requires nebulizer characteristics of 1.0 – 3.6 µm MMAD and Output 0.13 mL/min (±10%)
- Delivers twice the amount of methacholine versus 5-breathe dosimeter method
- Named Nebulizer: English Wright (Wright) Nebulizer
  - Continuous output, no air entrainment
  - MMAD 1.0 – 1.5 µm, 80% of aerosol is < 5.0 µm
  - Device requires calibration to get desired output rate
  - Has been discontinued by manufacturer (Roxon Medi-Tech)
In Vitro Evidence Supporting Use of the *AeroEclipse* II BAN

2 Minute Tidal Breathing Method
- Simulated Condition: Tidal Volume = 750 mL; 15 cycles/min; Inspiratory Time 1.6 seconds
- At 16 mg/mL, the English Wright deposition rate was $0.19 \pm 0.07$ mg/min and the *AeroEclipse* II BAN was $2.05 \pm 0.16$ mg/min
- 12 seconds of inhalation from the *AeroEclipse* II BAN would equal 2 minutes with the English Wright
- *AeroEclipse* II BAN was approximately 10 times faster than the English Wright

5 Breath Dosimeter Method
- Simulated Condition: 16 mg/mL, 3 L inhalation, Inspiratory Time 0.6 seconds
- At 16 mg/mL, The Devilbiss 646 deposition rate was $0.17 \pm 0.09$ mg/5 breaths and the *AeroEclipse* II BAN $0.74 \pm 0.04$ mg/5 breaths
- 1 inhalation from the *AeroEclipse* II BAN would equal 5 breaths with the Devilbiss 646
In Vivo Evidence Supporting Use of the AeroEclipse* II BAN

- $n=33$; convenience randomized, controlled crossover experiment with multiple protocols; participants aged 14.8 ± 6.8 years (17 male/16 female)
- Two different tests were conducted using the AeroEclipse* II BAN – a 30-second and a 20-second protocol versus the 2-minute protocol with the English Wright nebulizer
- The 20-second protocol had the closest correlation to the 2-minute tidal breathing method with results that suggest that when using dose delivered ($PD_{20}$), results are reproducible between the two nebulizer
- Data from both test protocols show that differences in nebulizer output and dose delivery mean that $PC_{20}$ is an unreliable measure of bronchial hyperreactivity
- Conclusion was that dose ($PD_{20}$), not concentration ($PC_{20}$), is the important determinant for bronchial responsiveness in MCT, a paradigm shift from current practice/guidelines
- Data suggests that alternate devices can be used providing users can accurately and precisely predict the dose delivered
- Results validate the use of the AeroEclipse* II BAN for methacholine challenge tests
2-Minute Tidal Breathing Comparison of Protocols

**English Wright Nebulizer**
- Inhalation (2 minutes)
- Spirometry
- Repeat Spirometry
- Next Inhalation (2 minutes)

**AeroEclipse* II BAN**
- Inhalation (20 sec)
- Spirometry
- Repeat Spirometry
- Next Inhalation (20 sec)

**Time (minutes)**

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8

30 s post inhalation
90 s post inhalation
1.5 min post repeat spirometry

Dosimetric Delivery with the *AeroEclipse* II BAN

- Aerosol is not generated during exhalation, between breaths or during breaks in treatment
- Dose delivered is consistent and linear\(^1\)
- Greater control of environmental loss since aerosol is only produced on inhalation
  - Actual environmental loss has been calculated at between 4-6.6%\(^1,2\)
- Incorporates air entrainment which increases delivery of respirable fine particles\(^3\)
  - Ideal respirable particle size – 78.4 % < 4.8 µm
- Cost effective, disposable device
  - No additional equipment or timing is required to start or stop aerosol production
  - No calibration is required to achieve the delivery protocols noted in the previous studies

AeroEclipse* II
Breath Actuated
Nebulizer
Device Set-Up
Instructions for Use

Devices come fully assembled in Breath Actuated Mode

Ensure mouthpiece is installed with the Exhalation Valve facing down
Setting Up Your Nebulizer

**To Remove**
Rotate 45° counterclockwise
Place prescribed medication into the nebulizer cup (max fill volume = 6 mL)

**To Reattach**
Align the top assembly with the stem in the bottom of the nebulizer
Rotate 45° clockwise
Setting Up Your Nebulizer

- Attach tubing to nebulizer and to flow meter
- Ensure both ends are securely engaged
- Set the flowmeter to 7-8 L/min with an air source capable of delivering 50 psi (344.7 kPa)
Methacholine Challenge Testing

- Sensitivity close to 100% - few false (-)
- Specificity 50% with PC 20 of 8mg/ml
- False (+) allergic rhinitis, CF, HF, COPD, smoking, viral infections
- 1 - 7% population with reactive airways
- 26% of smokers with reactive airways
- Not best test to say pt has asthma, but does R/O asthma
Mannitol Challenge Test

- Same indications as methacholine
- Dry powder capsule – easy to deliver in PCP office
- 9 step test 0 – 160mg, if FEV1 drops >10% but <15% repeat dose

- Stop when FEV1 drops 15% Predicted or >10% fall between 2 consecutive doses is positive
- PD 15 < cumulative dose 635mg is negative
Exercise/Dry Air Challenge

- Exercise with dry air
- Spiro 5, 10, 15, 20, 30 mins
- Monitor BP, EKG, SpO2, $V_E$
- Dry air – mouth valve/nose clips
- Treadmill, bike
- Goal 80% max hr
Eucapnic Voluntary Hyperventilation

- Dry air hyperventilation
- Similar effects as mannitol
- Olympic athletes
- Dry hypercapnic air breathed 30 bpm to achieve 85% MVV
- Spiro 0, 5, 10, 15 min.
- Positive test >10% decline in FEV1
Eucapnic Voluntary Hyperventilation Testing

- 5% CO₂
- 80% N₂
- 15% O₂

Flow meter

Reservoir

One-way Rudolph valve

Patient breathes at 30 x FEV₁ per min for 6 min

Positive test = 10% drop in FEV₁

Eucapnic voluntary hyperventilation testing

Case Study 38 yo Asthma - continued

- Evaluated by Allergist – DOE, after coming back from winter home
- Non-smoker, no history of asthma
- Daughter has asthma, during visit used her inhaler with some improvement
- Premarin 0.625 mg daily
- Physical normal
- CXR normal
- Spiro normal
- Echo normal
- CBC normal
Case Study 38 yo Asthma

- Clinical diagnosis made on improvement of DOE after using albuterol
- 3 weeks later using albuterol 3-4 times/day
- Spiro normal
- Added LABA and ICS (advair 100/50 bid)
- 3 days later patient called complaining of heart palpatations
- Changed fluticasone, FU in office in 2 weeks
- Office visit – still DOE, waking up at night, started on Montelukast
- Cardiopulmonary Arrest at airport after returning from visiting daughter
- Autopsy – reveals recent and remote pulmonary emboli
RTs add value to MD office

• # 1a – Best Qualified to work with MDs as physician extenders
• #1b – RTs are CRITICAL THINKERS!!!!
• RTs trained in Pulmonary Function Testing
• RTs trained in patient assessment
• RTs trained in patient education: asthma, copd, smoking cessation, medication management, etc.
• RTs – COPD educators
• RTs – Certified Asthma Educators
• RTs trained in allergy skin testing
• RTs trained in 6 min Walk, PR
• RTs trained in drawing blood
• RTs are great!!! And Patients Love US!
Use of a Respiratory Care Specialist in a Primary Care Practice Improves Outcomes

Rose Boehm, RRT, Pam Petersen, RN, Mary Hart, RRT, Mark Millard, MD, and Donald Kennerly, MD
Baylor Asthma and Pulmonary Rehabilitation Center, Baylor University Medical Center, Dallas, Texas

Abstract

Purpose: The Baylor Asthma and Pulmonary Rehabilitation Center employs RRTs and RNs who receive special training from asthma specialists and provide the majority of direct care by using flexible protocols. Objective: To evaluate whether the observed effectiveness of these respiratory care specialists (RCSs) in the specialty setting would also be observed in primary care.

Methods: For 121 adult patients with asthma and/or COPD in a primary care practice enrolled during the first 14 months of this program, the RCS provided evaluation services, discussed treatment recommendations with the primary care provider (PCP), and provided patient education.

Results: The effectiveness of this program was assessed with a pre-post analysis utilizing chart audit and several survey instruments in patients who received the RCS intervention and also a group that did not receive these intervention services. Significant improvements were observed in clinical outcomes and process of care measures described as goals by the NAEP. Formal spirometry for diagnosis and assessment of severity was increased from 26% of patients not receiving the RCS intervention to 100% for those who did; documentation of training in the use of inhaler devices increased from 15% to 90%; and formal chart documentation of the level of asthma control (weekly use of rescue inhaler) increased from 53% to 94%. Excluding patients evaluated during or shortly after a respiratory infection, the rate of rescue inhaler use dropped in patients who received the RCS intervention by 75% (geometric mean) while the "typical" daily symptom score dropped by 49% (geometric mean). An anonymous survey of PCPs to explore satisfaction with the intervention showed a mean score of 3.79 (1 to 4 scale).

Objective: To assess and document improved quality of asthma care using an RCS in a primary care setting.

Introduction

While the incidence of asthma and asthma morbidity has been well documented, the need for improvement in effective asthma management in the primary care provider (PCP) practice is still being documented. Due to the rising cost of health care and increased demands from both government and private insurance agencies, PCPs are required to see more patients in less time and provide services previously forwarded to specialty centers. In an effort to meet these demands, the PCP practice may sacrifice quality of care.

The Baylor Asthma and Pulmonary Rehabilitation Center employs RRTs and RNs who have received special training from asthma specialists (including but not limited to MDs and postgraduate programs). The majority of direct care is provided by these respiratory care specialists (RCSs) using flexible protocols in compliance with the NAEP guidelines.

Objective: To assess and document improved quality of asthma care using an RCS in a primary care setting.

Methods

Quality of care measurements and services:

- Spirometry—objective diagnostic documentation
- Inhaler technique—objective documentation and return demonstration
- Peak flow monitoring—documentation of technique and monitoring for changes (diaries)
- History of symptoms and documentation of changes
- Respiratory assessment
- Medications assessment
- Satisfaction survey
- Treatment recommendations
- Appropriate patient instruction


Results

Effectiveness of RCS intervention in the primary care setting:

- Formal spirometry for diagnosis and assessment of severity increased from 26% to 100%
- Rate of documentation of patient training in proper inhaler device technique increased from 13% to 90%
- Rate of documentation of quick-relief inhaled bronchodilator (IBD) use increased from 55% to 94%
- Rate of rescue inhaler use decreased by 75%
- Respiratory symptom score decreased by 49%

Chart Documentation

Financial impact:

- Additional revenue from performing procedures offset the RCS salary costs, so the intervention was cost neutral.

Conclusions and Clinical Implications

The RCS increases the quality of asthma care in the primary care practice by:

- Educating patients to increase trigger avoidance
- Training patients in proper device technique
- Educating patients about medications
- Providing timely, objective diagnostic testing
- Teaching asthma self-management

Since the RCS intervention was found to be clinically effective, well accepted by patients and PCPs, and cost neutral, it was chosen for dissemination to 44 other regional primary care practice sites affiliated with the HealthTexas Provider Network. The long-term clinical benefit imparted by the RCS intervention is being investigated.

Acknowledgment

The authors wish to acknowledge the contributions of Genia Tuckton, Fannie Halcomb, JoAnn Martin, RN, Lani Chaparro, RN, and Gretchen Lawrence, RRT.
Study

• 121 asthma patients  PCP office – 18 months
• RCS  (RT/RN) 1 day/week – certified asthma educators
• Pt assessment, spirometry, patient education, medication management, trigger/environmental control, self-management skills
• Use of albuterol, symptoms, rules of two, asthma action plan
• Patient and physician satisfaction
Results

- 26% to 100% Spirometry for diagnosis, severity, assessment
- 13% to 90% documentation/pt return demo of how to use medication delivery devices
- 55% to 94% Rate of Quick Relief Inhaler Use documented
- Rate of Quick Relief Inhaler Use Decreased by 75%
- Symptom Score Decreased by 49%
Benefits of RTs in PCP office

Patient Education
• Trigger Avoidance
• Proper Medication Device Technique
• How and When to use medications properly

Testing
• Timely, Objective Diagnostic Testing

Patient Responsibility – behavioral change
• Patient self-management
Methacholine Abstracts

Presented at ATS 2012
PROVOCATIVE DOSE 20, NOT PROVOCATIVE CONCENTRATION 20, DETERMINES BRONCHIAL HYPERRESPONSIVENESS IN CHILDREN WITH ASTHMA

S.S. Bola, R. Foty, L. Marshall, K. Nelligan, A.L. Coates, S. Dell (Toronto, ON/CA)

Rationale: International standards for methacholine challenge testing (MCT) to diagnose asthma recommend a 2 minute tidal breathing protocol with the English-Wright nebulizer (EW), the EW is now obsolete. Currently, the provocative concentration of methacholine causing a 20% drop in FEV1 (PC20) is recommended to determine the level of bronchial hyperresponsiveness, not the provocative dose (PD20). The objectives were to (1) determine if cumulative dose or concentration was the determinant for airway hyperresponsiveness and (2) validate an MCT using a modern, faster and environmentally safer delivery system, the breath actuated AeroEclipse™ II nebulizer (Aero).

Methods: Subjects aged 10 to 18 years, with physician diagnosed asthma, participated in multiple randomized, controlled crossover experiments comparing four different MCT protocols using standard methacholine concentrations and spirometry measurements but varying: (1) nebulizer used (EW versus Aero) (2) methacholine inhalation time (assumed to be directly related to dose delivered), and (3) methacholine starting concentration (to test for a cumulative effect). Total dose was based on total number of breaths and the in vitro performance characteristics of the nebulizer. Experiment A: 16 subjects EW protocol versus Aero with a 30 second inhalation time (Aero 30) Experiment B: 30 subjects EW protocol versus Aero with a 20 second inhalation time (Aero20) Experiment C: 13 subjects EW protocol versus Aero 30 protocol using the final methacholine concentration inhaled during experiment A as the starting concentration. Paired student T tests, intraclass correlation coefficients (ICC), and Bland Altman graphs were used to compare PC20 and PD20 obtained with EW versus Aero in each experiment.

Results: 33 children (17 male), aged 14.8 +/- 6.8 SD years, with median PC20 1.36 mg/ml (0.143- 32 mg/ml) participated. Comparison of PC20 between EW and Aero in experiments A, B and C demonstrated a statistically significant difference between the two nebulizers (Figures 1 and 2). Comparison of PD20 between EW and Aero in experiments A, B and C demonstrated no statistically significant difference (Figures 1 and 2). ICC for Experiment A PC20 and PD20 were 0.54 (0.11 – 0.80) and 0.64 (0.25 – 0.85) respectively and for Experiment B PC20 and PD20 were 0.62 (0.31 – 0.81) and 0.73 (0.48 – 0.87) respectively.

Conclusions: These results demonstrate that dose, not concentration, is the important determinant for bronchial responsiveness in MCT as dose of delivered methacholine accumulates and PD20 more accurately accounts for this cumulative effect. Our results also validate the use of the Aero for MCT.

See figures next 2 slides...
PROVOCATIVE DOSE 20, NOT PROVOCATIVE CONCENTRATION 20, DETERMINES BRONCHIAL HYPERRESPONSIVENESS IN CHILDREN WITH ASTHMA

S.S. Bola, R. Foty, L. Marshall, K. Nelligan, A.L. Coates, S. Dell (Toronto, ON/CA)

Comparison of Concentration (PC$_{20}$) and Dose (PD$_{20}$) for English-Wright and Aero-30

- English-Wright
- AeroEclipse 30s

<table>
<thead>
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<th>Concentration (mг/ml)</th>
<th>PC$_{20}$</th>
<th>PD$_{20}$</th>
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<tr>
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n = 16
p = 0.001

n = 16
p = 0.0901
PROVOCATIVE DOSE 20, NOT PROVOCATIVE CONCENTRATION 20, DETERMINES BRONCHIAL HYPERRESPONSIVENESS IN CHILDREN WITH ASTHMA

S.S. Bola, R. Foty, L. Marshall, K. Nelligan, A.L. Coates, S. Dell (Toronto, ON/CA)

Comparison of Concentration (PC_{20}) and Dose (PD_{20}) for English-Wright and Aero20

n = 30
p = 0.0038*

*Used conservative estimate of PC_{20}=32 for negative tests
REPLACING THE ENGLISH WRIGHT AND THE DEVILBISS 646 NEBULIZERS FOR METHACHOLINE CHALLENGE TESTS (MCT)

A.L. Coates, K. Leung, S. Dell (Toronto, ON/CA)

Rationale: In the 2000 ATS standard for performing MCT two delivery systems were proposed: the English Wright™ (EW) for two-minutes of tidal breathing and the DeVilbiss 646™ (Dev) for the 5 breath dosimeter method. The former is obsolete and hard to acquire, and the latter has variable output and an elaborate calibration scheme is necessary for both. Hence, many other delivery systems have come into use without standardization. This study evaluated other potential delivery systems for the MCT.

Methods: Devices compared were the breath actuated disposable AeroEclipse II BAN™ (AER) and the Viasys Aerosol Provocation System™ which uses the SideStream MedicAid Pro nebulizer to simulate the EW system. The AER only produces aerosol during inspiration which significantly limits environmental contamination. The protocol for the Viasys device suggests that 19 breaths would be equivalent to the 2-minutes EW tidal breathing method. Rates of output for the EW and AER were measured using a breathing simulator (modified Harvard Animal Ventilator, Hollistan MA) (tidal volume 750 mL, respiratory rate 15 and inspiratory time 1.6 seconds) and particle size distribution was measured by laser diffraction allowing the calculation of estimated pulmonary deposition of methacholine during in vivo two minute tidal breathing MCT. For the dosimeter method, an inhalation was simulated with a tidal volume of 3L over a 2-second duration, using a spirometry calibration syringe. A pulse of 0.6 seconds activated the DeV. In all cases, methacholine was eluted from filters at the “mouth” and assayed by high performance liquid chromatography (HPLC). The amount of methacholine captured at the “mouth” multiplied by the fraction of the mass of the aerosol carried in particles ≤ 5μm was the estimated pulmonary deposition.

Results: For a concentration of 16 mg/mL the rates of deposition for the EW and AER were 0.19±0.07 vs. 2.05±0.16 mg/min, indicating that 12 seconds of inhalation from the AER would be equivalent of two minutes with EW. The recommended 19 breaths for the Viasys deposited 0.80±0.06 mg or 0.04 mg/breath. The estimated pulmonary deposition was 0.17±0.02 mg for 5 breaths dosimeter method or 0.03 mg/breath.

Conclusions: It is clear that the EW has a very low rate of output compared to modern nebulizers. In order to change from one delivery system to another, adjustments of inhalation duration will be necessary. From these data it will be possible to design an in vivo study comparing modern aerosol delivery systems for MCT.

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Thank You!

hartmk@uthscsa.edu

This presentation is dedicated to Dr. Thomas L Petty – the man who inspired me to
“Think Outside the Box”
Not to accept the norm
Give back – Play it Forward
Never Give Up!