Evaluation of Exercise-Induced Dyspnea in the Pediatric Patient

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Case History

• 16 year old girl
• Mild, intermittent asthma X 2 years
• Track, tennis
• Penn Relays
• New exercise-related dyspnea
• Rapid onset, clears within few minutes of stopping exercise
• Hyperventilation in office: Stridor
Differential Diagnosis of Exercise-Related Dyspnea

- EIB
- Exercise-induced laryngeal obstruction
  - Vocal Cord Dysfunction
  - Exercise-induced laryngomalacia
- Exercise-induced hyperventilation
- Exercise-induced anaphylaxis
- GERD
- Exercise-induced cardiac disease
- Pulmonary hypertension
- Poor conditioning

Exercise-Induced Bronchospasm

- Common in athletes at all levels
- Symptoms variable and nonspecific
  - Chest tightness
  - Cough
  - Wheeze
  - Dyspnea
- Poor predictive value for objectively confirmed EIB
Exercise-Induced Bronchospasm

• With or without asthma
• Depends on both intensity and duration of exercise
• Defined as >10% drop in FEV₁ from baseline after exercise
• In asthmatics, related to sputum eosinophilia
  • allergen exposure increases response

Randolph C. Clinic Rev Allerg Immunol 34:205; 2008

Exercise-Induced Bronchospasm

• Cooling of airways
  • Reflex parasympathetic stimulation
    • Reflex bronchoconstriction and mucosal edema
• Water loss
  • Release of newly formed and preformed mediators
• Environmental exposures
  • Swimming, hockey, pollution
Prevalence of EIB

- Depends on population studied and methods to detect it
  - >90% in patients with persistent asthma
  - 30 - 70% in elite athletes
  - 5 - 20% of the general population

EIB in Trained Athletes

- Increased neutrophil counts in induced sputum from swimmers and winter athletes
  - Correlation with number of hours of training
- Increased eosinophil counts in swimmers
- 2 wks of rest resulted in reduced BHR

_Carlsen KH. Eur Respir J 38:713; 2011_
Estimated Prevalence of EIB or EILO Among Swedish Adolescents

Johansson H et al. Thorax 70:57; 2015

The Importance of Testing

- Retrospective review
- n = 148 athletes
- 12 – 57 yo
  - 61% college
  - 22% high school
  - 2% middle school
  - 15% adult recreational
  - 26% running
  - 18% swimming

Testing Prior to Referral

Hanks CD et al. Phys Sportsmed 40:28; 2012
Exercise-Induced Bronchospasm

- Ideal protocol
  - Rapid increase in exercise intensity over 2-4 min
  - Dry air (<10 mg H2O/L)
  - Nose clips
  - Exercise at load to raise HR to 80-90% max
  - Continue at that level for 4-6 min
  - Measure FEV-1 baseline, 5,10,15, and 30 min


The Exercise Challenge

- Response expressed as % fall in FEV-1 from baseline
  - ≥ 10% fall = positive response
- Severity
  - ≥ 10% to < 25% Mild
  - ≥ 25% to < 50% Moderate
  - ≥ 50% Severe

Recommended Therapies

- SABA 15 min before exercise
- Add controller if SABA used ≥ daily
- Daily leukotriene receptor antagonist
- Mast cell stabilizing agent before exercise
- Inhaled anticholinergic agent before exercise
- Interval or combination warm-up exercises
- Avoid
  - LABA
  - ICS alone

Forced Flow-Volume Loop
**Case History**

- 17 year old high school junior
- Competitive swimmer (scholarship)
- With activity, “high-pitched inspiratory wheeze”
- Unable to swim, even during practice
- No problems with other sports
- Unresponsive to inhaled steroids and bronchodilators

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**Olfactory Stimulation**

![Baseline](Baseline.png)  ![After Chlorine](After_Chlorine.png)
VCD: Definition

Episodic adduction of the vocal folds during inspiration and/or expiration,
resulting in partial obstruction of the extrathoracic airway and symptoms of dyspnea, neck or throat tightness, and stridor.

Pediatric VCD

- Early information from case reports
- Stressed association with psychiatric and emotional problems
- Noted excessive treatment for chronic asthma
- No gender predilection in early reports
Retrospective Review of VCD

- n = 37, 4 - 19 years old (x = 13 years)
- 68% female, 81% Caucasian
- 84% Academic achievers
- 61% Athletes
- 33% previous psychiatric illness
- 70% individual or family dysfunction
- 11% with identified sexual abuse, suspected in another 16%


Exercise-Induced Paradoxical Arytenoid Motion

Exhalation  Inhalation

Tilles SA. Ann Allergy Asthma Immunol 104:361; 2010
"Susceptible Larynx" Syndrome

Susceptible Larynx → GERD → Exercise → Symptoms
 réalisation → anxiety


Flow-Volume Loop Shapes

Pandit CA et al. J Paed Child Health 50:829; 2011
Continuous Exercise Laryngoscopy


Continuous Exercise Laryngoscopy

Glottic

Supraglottic

From: Roksund OD et al. Respira Med 103:1911; 2009
(Exercise) Inducible Laryngeal Obstruction

- Supraglottic
  - Arytenoids, epiglottis, vestibular folds
- Glottic
  - Vocal folds
- Both supraglottic and glottic

- Phase
  - Inspiratory, expiratory, biphasic


VCD: Anxious Over-Achievers?

<table>
<thead>
<tr>
<th>Age and Gender</th>
<th>Psychiatric Diagnosis</th>
<th>Academic Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 F</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>12 F</td>
<td>Anxiety Disorder</td>
<td>A</td>
</tr>
<tr>
<td>14 F</td>
<td>Depressive Disorder</td>
<td></td>
</tr>
<tr>
<td>12 F</td>
<td>Anxiety Disorder, Depressive Disorder</td>
<td></td>
</tr>
<tr>
<td>15 M</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>16 F</td>
<td>Depressive Disorder</td>
<td>A</td>
</tr>
<tr>
<td>18 F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Landwehr, LP. Pediatrics 98:971; 1996
Psychological Issues

- Immature personality / family conflict
- Anxiety disorder / Depressive disorder
- Competitive personality
- Little tolerance for failure
- Recent advance to higher level of competition
- High academic and performance standards
- Parental pressure to succeed


VCD vs EIB

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>VCD</th>
<th>EIB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situation dependent</td>
<td>Reproducible</td>
<td></td>
</tr>
<tr>
<td>Abrupt onset and end</td>
<td>Peak in 5 – 10 min</td>
<td></td>
</tr>
<tr>
<td>Distraction</td>
<td>Resolve within 30 – 60 min</td>
<td></td>
</tr>
<tr>
<td>Cold or dry air</td>
<td>Cold or dry air</td>
<td></td>
</tr>
<tr>
<td>Persistent cough</td>
<td>Persistent cough</td>
<td></td>
</tr>
<tr>
<td>Sensation of tightness</td>
<td>Throat</td>
<td></td>
</tr>
<tr>
<td>Stridor or Wheeze</td>
<td>Audible inspiratory stridor</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>Breathing exercise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expiratory wheeze</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beta agonist</td>
<td></td>
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</tbody>
</table>
### Pulmonary Function Tests

<table>
<thead>
<tr>
<th></th>
<th>VCD</th>
<th>EIB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspiratory loop</td>
<td>Truncated or flattened</td>
<td>Normal</td>
</tr>
<tr>
<td>FVC N or ▼</td>
<td></td>
<td>Usually ▼</td>
</tr>
<tr>
<td>FEV₁ N or ▼</td>
<td></td>
<td>▼ &gt; 20%</td>
</tr>
<tr>
<td>FEF_{25-75%} N</td>
<td></td>
<td>▼</td>
</tr>
<tr>
<td>FEV₁ / FVC No change</td>
<td></td>
<td>FEV₁ ▼ &gt; FVC ▼</td>
</tr>
<tr>
<td>FEF_{50} / FIF_{50} Ratio &gt; 1</td>
<td></td>
<td>Ratio &lt; 1</td>
</tr>
</tbody>
</table>

Adapted from Koester MC and Amundson CL. J Athletic Train 37:320; 2002

### E-ILO Therapies

- Breathing exercises
- Psychological counseling
- GERD therapy
- Treatment of postnasal drip
- Ipratropium
- Surgery
Breathing Exercises for Dysfunctional Breathing

• Cochrane review
• Breathing techniques in children <18
• NO Studies identified that fulfilled criteria
• Some studies in adults point to utility of various breathing exercises

Barker NJ et al. Cochrane Database of Systematic Reviews. 12; 2013

Long Term Outcomes of VCD

• 13 year retrospective review
• N = 49
  • Laryngoscopy (n = 24)
  • Spirometry (n = 8)
  • History (n = 17)
• 2 patterns described
  • Exercise-induced VCD (EIVCD) (n = 29)
  • Sudden onset VCD (SVCD) (n = 20)
  • Both (n = 4)

Doshi DR and Weinberger MM. Ann Allergy Asthma Immunol 96:794; 2006
Follow Up Structured Interviews

- N = 28, 0.5 - 12 (median 3) years
- Eventual resolution in 26
  - 11 (8 F) SVCD
    - 10 (91%) without symptoms
  - 17 (10 F) EIVCD
    - 16 (94%) without symptoms
    - 8 followed with Speech therapy
    - 6 prescribed Ipratropium

Doshi DR and Weinberger MM. Ann Allergy Asthma Immunol 96:794; 2006

Surgery for Supraglottic EILO

Exercise-Induced Symptoms and Cardiac Disease

- Hypertrophic Cardiomyopathy
- Dysrhythmias
  - Prolonged QT syndrome
  - Supraventricular tachycardia
  - Congenital malformations
    - Valvular disease
      - Anomalous coronary artery anatomy
    - Pulmonary hypertension
- Congenital malformations
- Valvular disease
- Anomalous coronary artery anatomy
- Pulmonary hypertension

Clues to A Cardiac Etiology

- Symptoms
  - Syncope
  - Palpitations
  - Irregular heart beat
- Other findings
  - Hypertension
  - Pathologic murmur
- Family History
Evaluation: History

• Site of obstruction
• Dysphonia, dysphagia
• Onset and cessation
• ? Triggers
  • Exercise, exertion, hyperventilation
  • Stress
  • Dust, smoke, fumes, odors, chemicals
• Timing
  • ? During sleep?
• Response to anti-asthma therapies

Evaluation

• Physical examination
  • Overall
    • Bright
    • Anxious
    • Body habitus
  • Auscultation
    • Normal
    • Stridor with panting or hyperventilation
  • Non-pulmonary findings
Evaluation

- Exercise challenge
- Laryngoscopy
  - Hypnosis¹
  - Olfactory Challenge²,³
  - Hyperventilation
  - *Exercise
- Flow-volume curve

¹Anbar RD and Hehir DA. Pediatrics 106:E81; 2000

Summary

- Exercise-related dyspnea is common
- Testing required for accurate diagnosis
- Exercise challenge good first step
  - Formal
  - Field
  - Video
- High degree of successful treatment