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Age Appropriate Assisted Airway Clearance Techniques for Children

Christopher M. Oermann
Children's Mercy Hospital

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Christopher M Oermann, MD

Division Director, Pulmonary and Sleep Medicine,
Children's Mercy Kansas City

Professor of Pediatrics, University of Missouri
Kansas City School of Medicine

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- I have no relevant financial relationships with the manufacturer(s) of any commercial product(s) and/or provider(s) of commercial services discussed in this CME activity
- I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation

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Changes in Practice

- Eliminate the use of assisted airway clearance for disease processes for which it is not indicated
- Use physiologically and age appropriate methods of assisted airway clearance when indicated

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Goals and Objectives

- Describe normal airway clearance and the disease processes for which assisted airway clearance therapy is indicated
- Explain the physiologic rationale for and data supporting use of various assisted airway clearance techniques used among children
- Develop an age and diagnosis appropriate airway clearance plan for a child with impaired airway clearance

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Normal Airway Clearance

- Airway anatomy and physiology
- Respiratory Epithelium
- Innate airway clearance mechanisms
  - Cough
  - Mucociliary Escalator
  - Cephalad Airflow Bias

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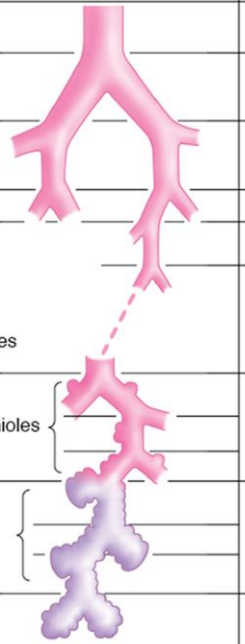
	Name of branches	Number of tubes in branch	Cilia	Muscle	Glands
Conducting zone	Trachea	1	Yes	Yes	Diffuse
	Bronchi	2	Yes	Yes	Scattered Sparse
		4			
		8			
	Bronchioles	16	Yes	Yes	No
		32			
	Terminal bronchioles	6×10^4			
Respiratory zone	Respiratory bronchioles	5×10^5	Some	Some	No
	Alveolar ducts		Minimal	Minimal	No
	Alveolar sacs	8×10^6	None	No	No



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Conducting Zone
- Cough
- Cephalad airflow bias
- Mucociliary escalator

Respiratory Zone
- Cephalad airflow bias
- Alveolar macrophages
- Chemical absorption

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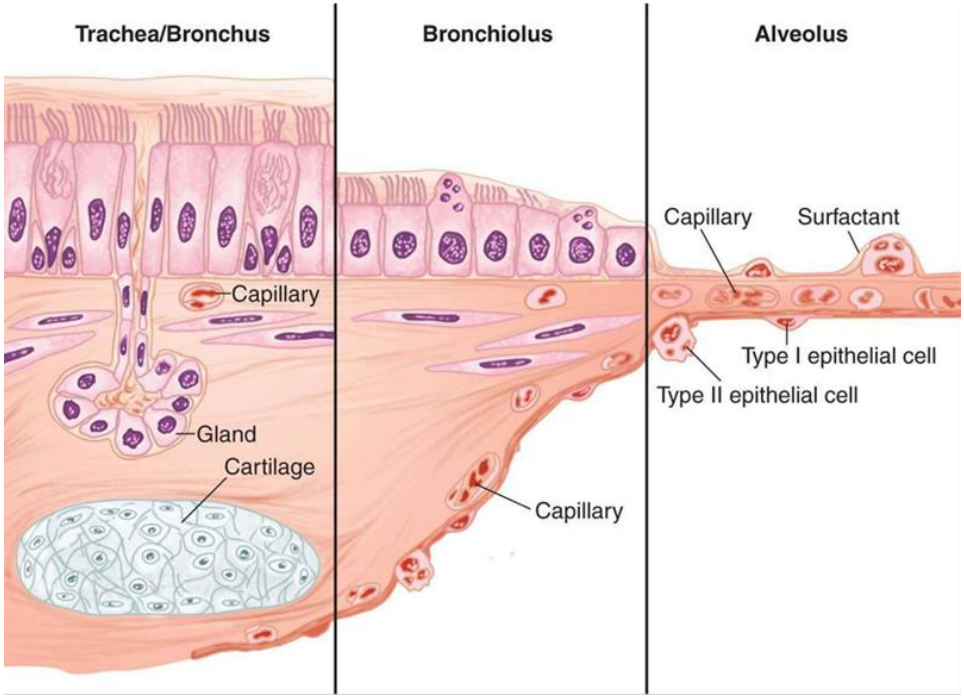
Respiratory Epithelium

- Large airways are rich in goblet cells and submucosal glands which produce mucus
- Medium airways have decreasing quantities of goblet cells and submucosal glands
- Small airways (bronchioles and distal) do not produce mucus



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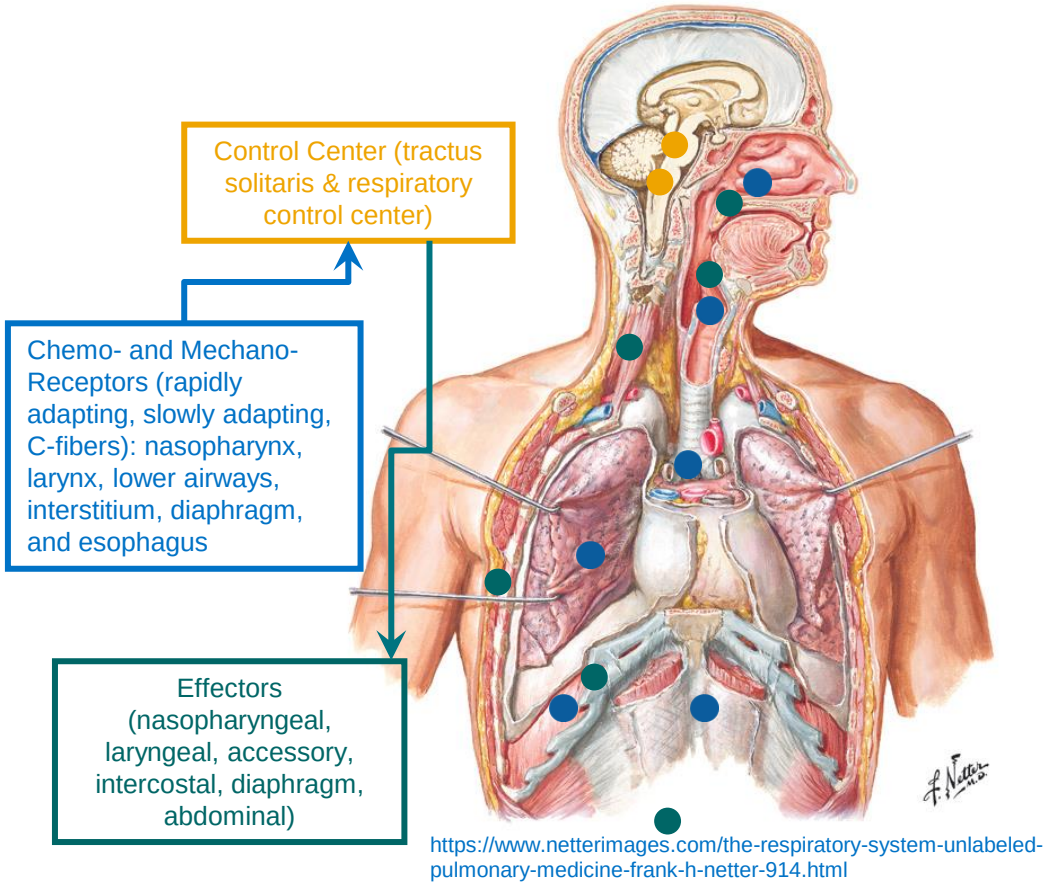
Cough

- Healthy children cough up to 11 times per day - airway protection, normal airway clearance
- Reflex
  - Deep inspiration
  - Glottic closure
  - Muscle contraction
  - Glottic opening



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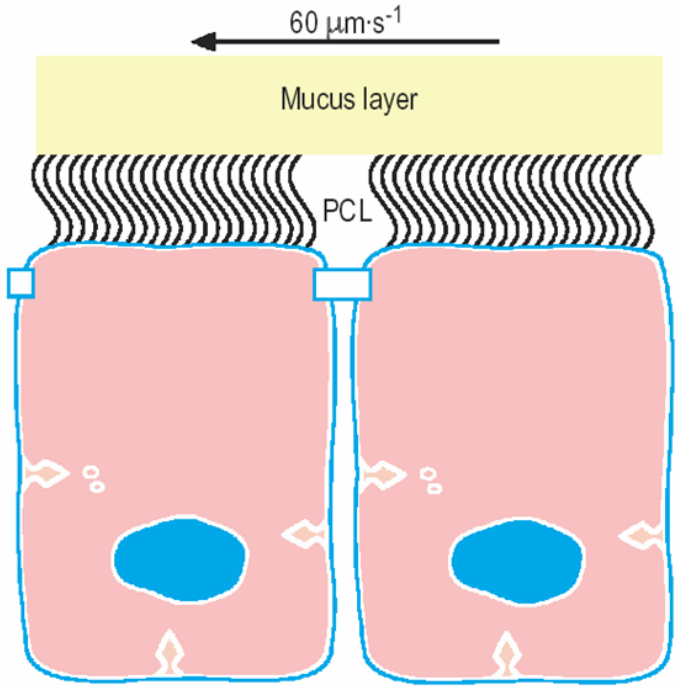
Mucociliary Escalator

- Gel Layer (high viscosity and elasticity)
- Sol Layer (low viscosity and elasticity)
- Rapid movement in extension to propel material in gel phase
- Slow return in flexion to starting position, traveling through sol phase
- Most effective in small airways due to large cross-sectional area



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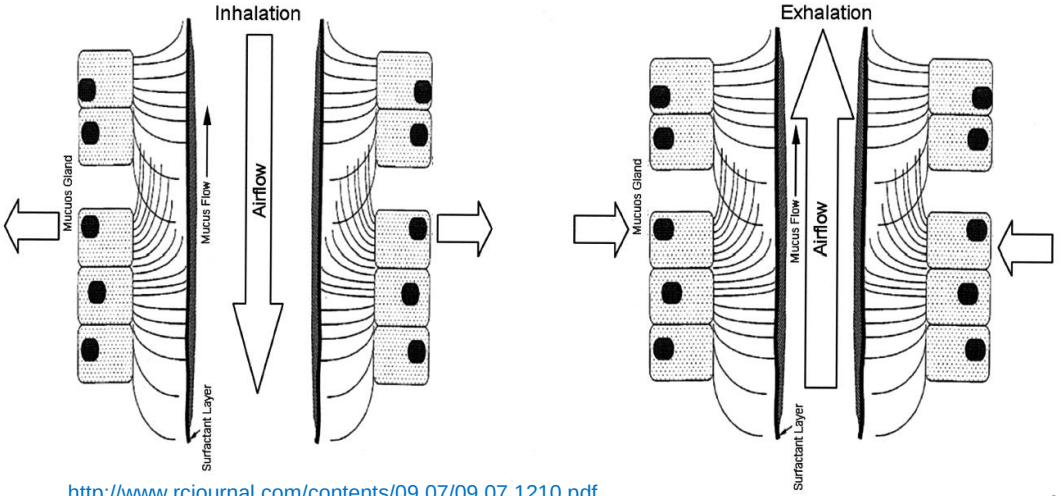
Cephalad Airflow Bias

- Decreased airway diameter during exhalation results in increased flow velocity
- Increased airflow velocity shears secretions and drives material in direction of flow
- Present in large and small airways but is the primary mechanism of transport in smaller conducting airways



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Physiologic Approach to AACT

- Disease processes for which AACT is indicated
  - Increased airway secretions
    - Inhalation/aspiration injuries
  - Impaired clearance of secretions
    - Impaired mucociliary clearance
      - Bronchiectasis; CF
      - PCD
  - Decreased cough efficacy
    - Neuromuscular weakness

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- Disease processes for which AACT is **not** indicated
  - Bronchiolitis
    - Numerous poor quality studies demonstrating conflicting results
    - Several Cochrane reviews citing no evidence of benefit
  - Pneumonia
    - No physiologic rationale for use
    - No studies indicating benefit
    - Cochrane reviews citing no evidence of benefit

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- Asthma
  - Multiple studies and reviews demonstrating no benefit
- Routine post-operative management
  - No literature to support routine use
    - Appropriate for patients with underlying disease
    - Appropriate for significant post-operative atelectasis
- Mechanically ventilated patients
  - Several studies failing to demonstrate benefit
    - Associated with ↓ O2 saturations and ↑ HR, ICP, BP
  - Potential use in patients with significant atelectasis

- Physiologically appropriate AACT
  - Conducting Zone
    - Improve cough efficacy
    - Enhance function of mucociliary escalator
    - Increase cephalad airflow bias
  - Respiratory Zone
    - Increase cephalad airflow bias
    - Nothing to stimulate alveolar macrophages
    - Nothing to alter chemical absorption

AIRWAY CLEARANCE THERAPIES

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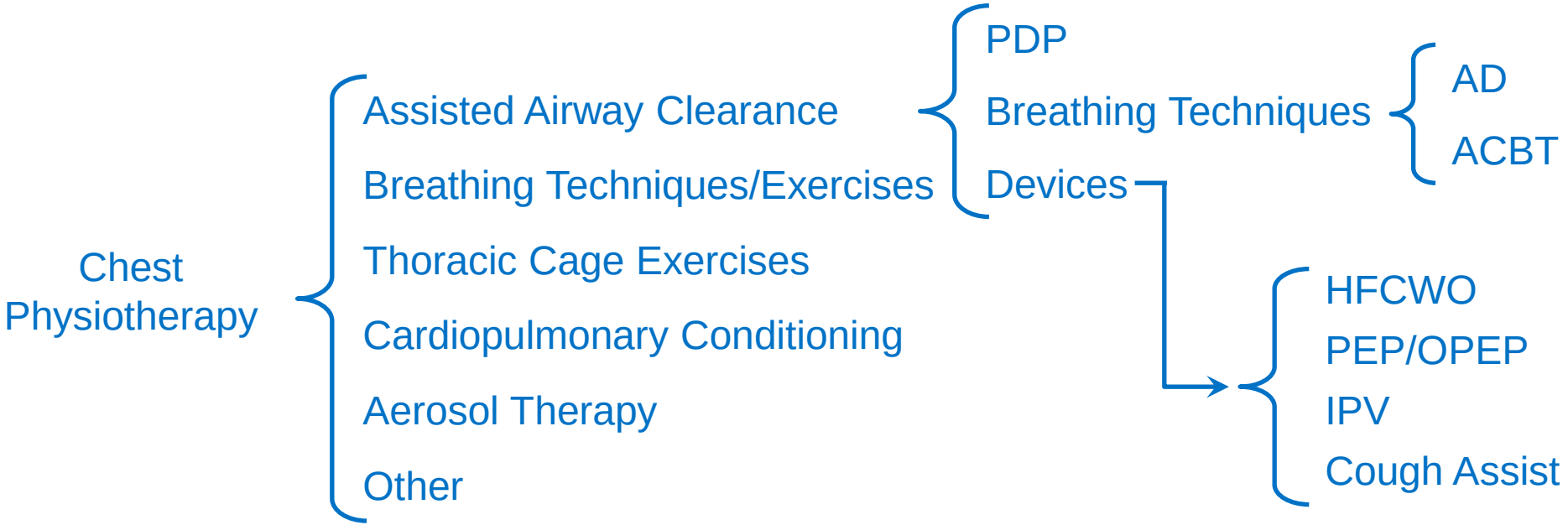
One of My Many Pet Peeves
What is CPT?



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CPT ≠ AACT≠ PDP

Postural Drainage and Percussion

- Physiology
  - “Gold Standard” for airway clearance for many years
  - Postural drainage relies on gravity-enhanced secretion clearance
  - Percussion helps to vibrate airways, shearing secretions
  - Vibration largely abandoned

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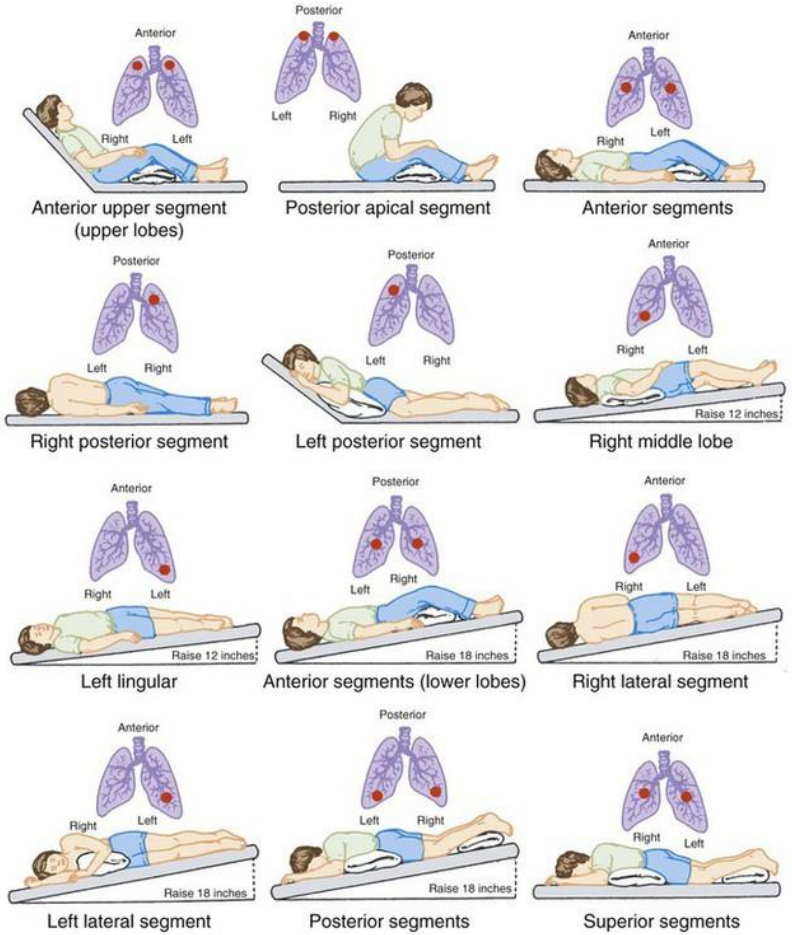
- Therapy
  - Use 6-12 positions
  - Percussion of 3-4 minutes per position
  - Controlled breathing and huffing/FET maneuvers between positions
  - Contraindicated in circumstances where there are concerns for ↑ ICP, HTN, hemoptysis, GERD, coagulopathy, etc.



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- Pro
  - All ages
  - No cost (time)
  - Portable
  - Familiarity and ease of use
- Con
  - Passive
  - Requires providers
  - GERD
  - Hypoxemia

- Data
  - ↑ sputum volume
  - ↑ FVC and PEF immediately after treatment
  - ↓ spirometry without therapy
  - Meta-analysis suggests that any therapy is better than no therapy
  - Cochrane reviews: no compelling evidence that airway clearance is beneficial for long-term use; limited support for short-term use

Autogenic Drainage

- Physiology
  - Developed in late 1960's in Belgium
  - Tidal breathing at various lung volumes starting from low to high
  - "Milks" secretions from smaller to larger airways by producing high-velocity air flow in different generations of airways
  - Huff at end of cycle allows clearance from largest ways

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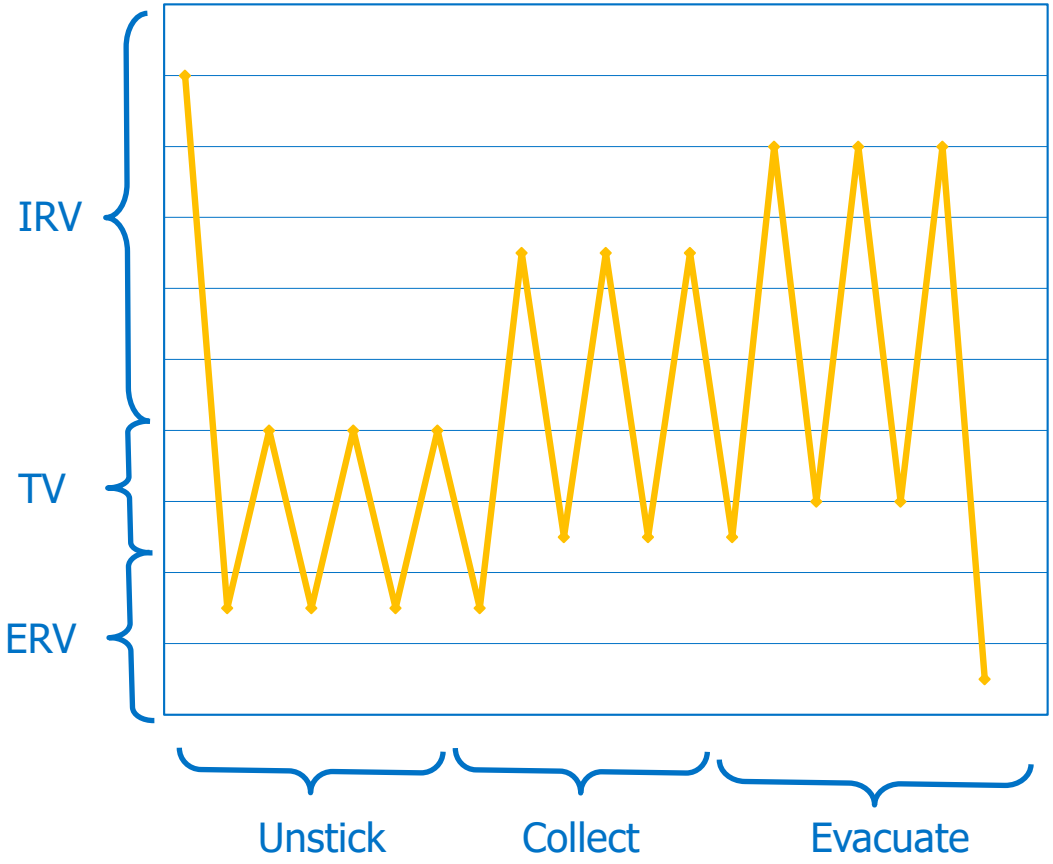

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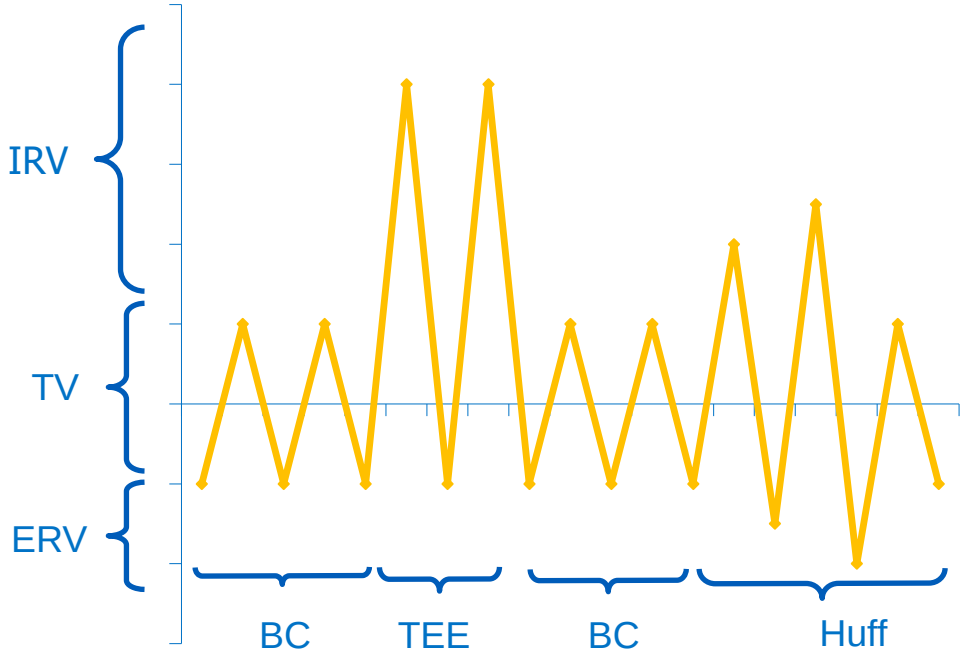
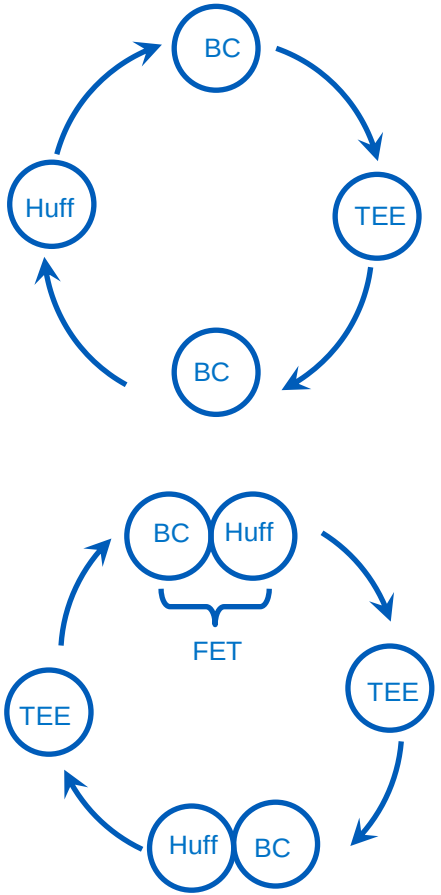
- Pro
  - Active
  - Independence
  - No cost
  - Portable
- Con
  - Motivated, intelligent, older (> 12 years) patient
  - Difficult to learn

- Data
  - ↑ sputum expectoration
  - ↓ desaturation
  - As effective as PDP
  - Preferred to PDP by patients

Active Cycle of Breathing Technique

- Physiology
  - Developed in late 1960's in New Zealand
  - Combines breathing control exercises (BC), thoracic expansion exercises (TEE), and huffing
  - TEE lead to greater collateral ventilation and movement of secretions from peripheral to central airways
  - Huffing allows expectoration of accumulated secretions





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- Pro
  - Active
  - Independence
  - No cost
  - Portable
- Con
  - Motivated, intelligent, older (> 12 years) patient

- Data
  - Equivalent to PDP
  - ↓ desaturation
  - ↑ independence

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HFCWO

- Physiology
  - Decreases mucus viscosity
  - Increases cough-like shear forces
  - Increases airflow bias
  - Mechanical vibration of airways
  - Increased cilia beat frequency
- Systems
  - Air pulse generator, large bore tubing, inflatable vests
  - Variable pressures generated
  - Variable frequencies possible

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- Therapy
  - 20-30 minutes at least BID and more often during illness
  - Vary frequency to move secretions from smaller to larger airways
  - Intermittent deep breathing and huffs between frequencies

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- Pro
  - Independence
  - Ages > 2 years
  - Easy to use
- Con
  - Passive
  - Cost
  - Lack of portability

- Data
  - Equivalent to PDP with respect to spirometry
  - ↑ sputum clearance
  - Improved sputum rheology
  - ↑ patient satisfaction

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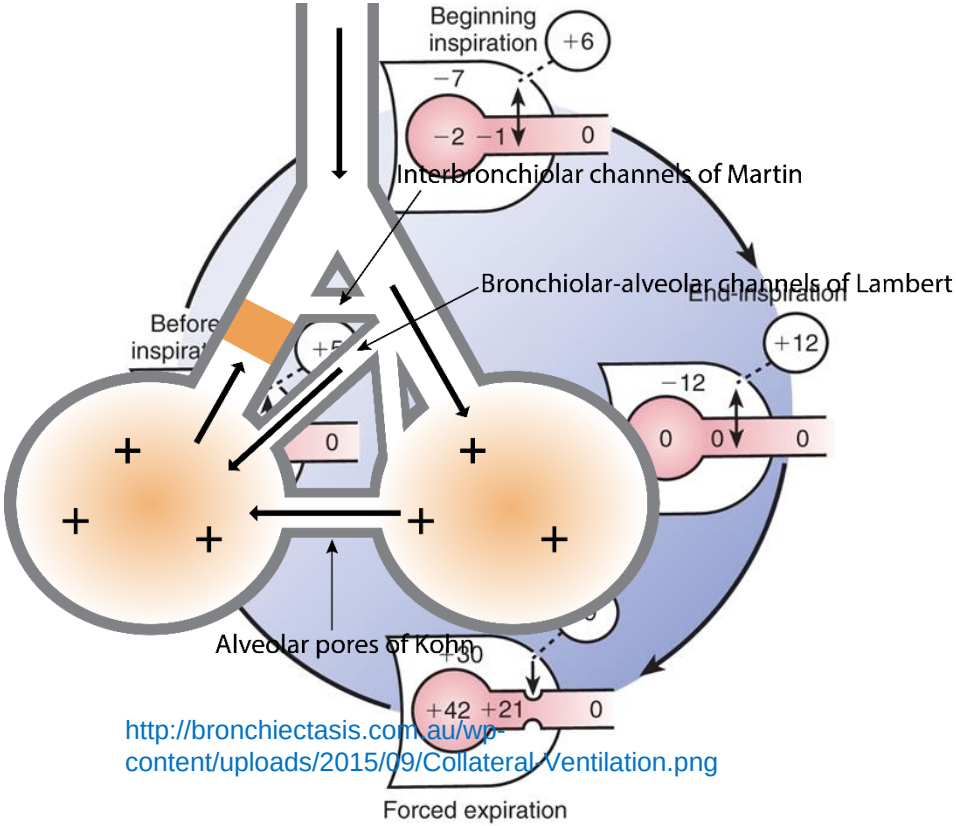
PEP and OPEP

- Physiology
  - Prevents airway collapse by stenting at EPP
  - Allows ventilation of obstructed airspaces via collaterals
  - Airway wall vibration loosens secretions



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- Devices
  - Non-oscillating
    - One-way valve and variable airflow resistor
    - High (25-100 cm H2O) or low (5-20) pressure
  - Oscillating
    - Various designs
      - Variable pressure
      - Variable frequency

- Therapy
  - Tidal breathing for 10-15 breaths
  - 15-20 breaths against resistance
  - FET/Cough/Huff
  - Repeat
  - 20-30 minutes total

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- Pro
  - Active
  - Independence
  - Five years and older
  - Low cost
  - Portable
  - Easy to use
- Con
  - ????

- Data
  - Most trials suggest equivalence to other forms of airway clearance and possible superiority to PDP
  - Variable results for sputum clearance
  - High patient acceptance

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Intrapulmonary Percussive Ventilation

- Physiology
  - Benefits of PEP
  - Benefits of airway vibration
- Device
  - Variable pressure and frequency
  - Used with mouthpiece or mask
  - Aerosol therapy may be done inline
- Therapy
  - Generally 15-2(minute therapy
  -

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- Pro
  - Most useful for atelectasis and neuromuscular patients
- Con
  - Cost
  - Lack of portability
  - Not easy to use

- Data
  - Several studies demonstrating equivalence to PDP
  - More sputum production than IS in neuromuscular patients
  - Benefits in COPD

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Insufflation/Exsufflation

- Physiology
  - Positive inhalation and negative exhalation pressures
    - Improves chest wall expansion
    - Improves collateral ventilation
    - Suctions secretions from large airways
- Device
  - Variable pressures/flow
  - Variable inhalation/exhalation times
  - Pause time
  - Different interfaces
  - Inline aerosol therapy

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- Pro
  - Most beneficial for muscle weakness diseases
- Con
  - Cost
  - Patient cooperation essential
  - May not be well tolerated

- Data
  - Numerous studies in several neuro-muscular diseases
  - Decreased hospitalization rate, increased secretion clearance, decreased atelectasis

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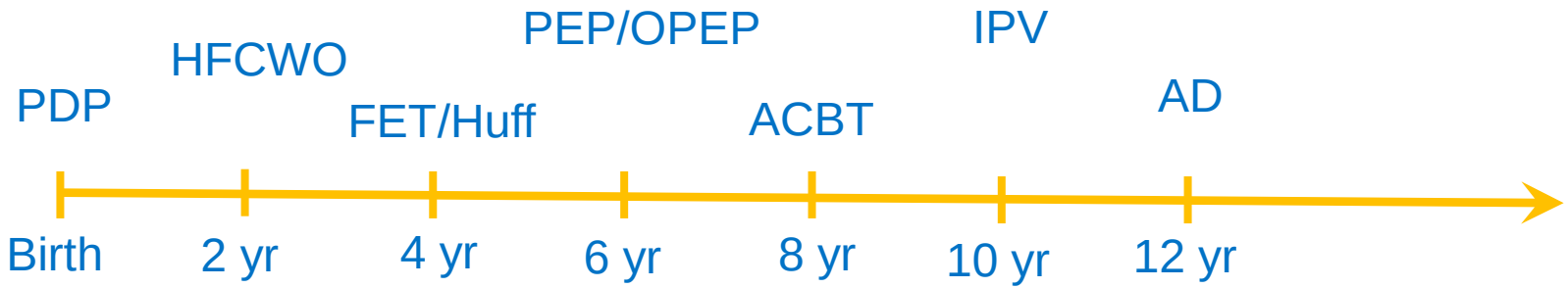
Choosing the Right AACT

- Obstructive diseases



- Restrictive diseases
  - Insufflator/Exsufflator

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- Consider
  - Cost
  - Convenience
  - Patient preference
  - Proven disease-specific efficacy
  - Subjective patient-specific efficacy

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