

Lung Clearance & Expansion Techniques

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This Presentation is Approved for
2.0 CRCE Credit Hours

Learning Objectives

- Describe the current information on techniques used for lung clearance & expansion

Mucociliary Transport

Respiratory Romance Poem

When you're kissing your honey
And her nose gets runny
Don't think it's funny
It's not

Functions of Mucus

- Traps foreign particles for removal
- Humidifies inspired air
- Prevents infection
- Dilutes toxins
- Neutralizes toxic gases
- Buffers pH

Mucus

- Composition
 - ❖ H₂O 95%
 - ❖ Mucins
 - Complex glycoproteins
 - Two primary types: MUC5AC, MUC5B
 - Bind bacteria - decrease infections

Mucus

- Composition
 - ❖ H₂O 95%
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 - Complex glycoproteins
 - Two primary types: MUC5AC, MUC5B
 - Bind bacteria - decrease infections
 - ❖ Carbohydrate, SO₄
 - ❖ Proteins: IgE, IgM, IgA, lysozyme
 - ❖ Oxidants, antioxidants
 - ❖ Surfactant

Sources of Mucus

- Normal production = 10 - 20 ml/day
- Goblet cells
- Submucosal glands
- Clara cells - defensive secretions
- Serous cells - defensive secretions
- Type II pneumocytes - surfactant
- Epithelial cells - transport Cl & Na H₂O follows

Mucus - Control of Secretion

- Parasympathetic
 - ❖ Muscarinic receptors in submucosal glands
 - ❖ Stimulation increases secretion
 - ❖ Blocking decreases secretion, e.g. anticholinergic agents (atropine)

Mucus - Control of Secretion

- Sympathetic (adrenergic)
 - ❖ There is no adrenergic innervation of secretory structures
 - ❖ Adrenergic influence is through circulating catecholamines
 - ❖ Catecholamines increase secretion
- Inflammatory mediators - increase secretion

Mucus - Control of Secretion

- Non-adrenergic, non-cholinergic (NANC)
 - ❖ Neurotransmitters
 - Vasoactive intestinal peptide
 - Tachykinin
 - ❖ Stimulate secretion

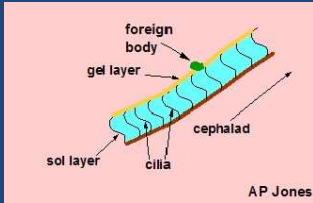
Control of Transport

- Mucociliary clearance
- Tidal expiratory flow
- Forced expiratory flow (cough)

Pulmonary Clearance Mechanisms

- > Cilia
 - ❖ Line epithelium to terminal bronchi
 - ❖ Beat in metachronal wave @ 10 - 20 Hz

Mucociliary Escalator



Up next: Video of ciliary metachronal wave (11 sec)

Factors Affecting Ciliary Motility

- > Increase ciliary motility
 - ❖ Adrenergic agents
 - ❖ Cholinergic agents
- > Decrease ciliary motility
 - ❖ Alcohol
 - ❖ Hereditary dx - ciliary dyskinesia
 - ❖ Increased mucus viscosity
 - ❖ Smoke
 - ❖ Infection

Transport Abnormalities

- > Abnormal mucus
 - ❖ Chronic bronchitis
 - ❖ Asthma
 - ❖ Cystic fibrosis
- > Ciliary dyskinesia - immotile cilia
- > Drying
- > Cough impairment

Transport Abnormalities

- > Chronic bronchitis
 - ❖ Increased mucus glands at expense of other cells (Increased Reid index)
 - ❖ Increased depth of mucus layer
 - ❖ Decreased mucociliary clearance
 - ❖ Worsened with continued smoking

See links below to view microscopic images of Reid index

Transport Abnormalities

- > Asthma
 - ❖ Mucous plugging with eosinophilic sputum
 - ❖ Bronchial casts

See links below to view bronchial cast

Transport Abnormalities

- > Cystic fibrosis: hereditary defect of secretory glands
 - ❖ Defective gene encodes cystic fibrosis transmembrane regulator (CFTR)
 - ❖ CFTR affects ion transport across airway epithelium - exact physiologic action is controversial
 - ❖ Airway surface liquids are decreased, increasing mucus viscosity & adhesiveness

Transport Abnormalities

- > Cystic fibrosis
 - ❖ Chronic airway obstruction with mucus → infection
 - ❖ Neutrophils release proteases → inflammation & airway remodeling (bronchiectasis)
 - Worsens mucus clearance
 - Loads mucus with DNA

Transport Abnormalities

- > Cystic fibrosis
 - ❖ Colonization with pseudomonas produces biofilm that increases resistance of organisms to antimicrobials

Transport Abnormalities

- > Hereditary ciliary dyskinesia (Kartagener's syndrome)
 - ❖ Immotile cilia → impaired mucus clearance → recurrent infection → bronchiectasis

Transport Abnormalities

- > Drying of mucus → increased viscosity
 - ❖ Inadequate humidification of inspired air, especially with bypassed airways
 - ❖ Ventilation increased above capabilities of airways to humidify
 - Exercise
 - Noninvasive ventilation - we need to humidify BiPAP

Transport Abnormalities

- > Cough impairment
 - ❖ Artificial airways
 - ❖ Neuromuscular weakness
 - ❖ Pain

Consequences of Impaired Transport

- Mucus plugging - atelectasis
- Infection
 - ❖ Pneumonia
 - ❖ Recurrent pneumonia - bronchiectasis

Patient Assessment For Mucokinetic & Lung Expansion Therapy

Symptoms

- Shortness of breath
- Cough
- Mucus production
- Wheezes

Physical Signs

- Fever - NOT for atelectasis
 - Thick mucus &/or plugs
 - Tachypnea
 - Accessory muscle work
 - Asymmetric chest motion (severe)
 - Tracheal shift (severe)
- FYI see links below for articles on fever & atelectasis

Physical Signs

- Breath sounds
 - ❖ Diminished or absent
 - ❖ Rhonchi
 - ❖ Wheezes
 - ❖ Crackles (atelectasis, pneumonia)
 - ❖ Bronchial (tubular) sounds
- Cyanosis (severe)
- Increased peak inspiratory pressure

Spirometry

- Decreased FVC, IC
- Decreased PEF, FEV₁

Blood Gases

- > Hypoxemia - V/Q mismatch
- > Hypercapnia
 - ❖ When superimposed on COPD
 - ❖ Severe tachypnea → increased dead space

Radiologic Signs

- > Atelectasis - especially with plugging
- > Pneumonia

See links below to view chest X-rays of severe lobar atelectasis & atelectasis

Pharmacological Mucokinesis

Issues With Mucokinetic Agents

- > Different condition → different mucus characteristics
- > Viscosity
 - ❖ Excessive viscosity impairs cilia
 - ❖ Decreased viscosity may impair clearance
 - ❖ Cilia may not mobilize very thin secretions (swimming in air)
 - ❖ Thin secretions flow to dependent lung

Issues With Mucokinetic Agents

- > Adhesiveness impairs clearance – secretions stick to airways

Beta Adrenergic Agents

- > Bronchodilation may enable secretion mobilization - enlarged airways loosen plugs
- > Mucociliary effects
 - ❖ Increase ciliary motility
 - ❖ Increase mucus production

Beta Adrenergic Agents

- Clinical outcomes
 - ❖ Short-acting beta-adrenergics: no benefits on clearance
 - ❖ Long-acting beta-adrenergics, e.g. salmeterol: modest benefits

Mucokinetic Agents

- Expectorants: increase mucus production
- Mucolytics: reduce mucus viscosity
- Surfactants: reduce mucus adhesiveness
- Hypertonic saline
- Bland aerosols
 - ❖ No benefits
 - ❖ May harm - bronchospasm, etc.
 - ❖ No further discussion

Expectorants

- Potassium iodide (SSKI): acts directly on mucus glands
- Indirect-acting expectorants: irritate gastric mucosa, stimulating cholinergic receptors to stimulate secretion
 - ❖ Guaifenesin (Mucinex)
 - ❖ Elixir terpin hydrate (AKA GI gin)

OTC Cold Medications

- Does this make sense? Combining an agent to increase mucus secretion with another agent to suppress cough?

Mucolytics

- N-acetylcysteine (Mucomyst)
- Dornase alfa (Pulmozyme)
- Sodium bicarbonate
 - ❖ No benefits
 - ❖ May harm

N-acetylcysteine (Mucomyst)

- Oral administration (200 mg TID)
 - ❖ May improve pulmonary function
 - ❖ May reduce risk of hospitalization
 - ❖ Reduced exacerbations
 - ❖ Reduced days of illness
 - ❖ Reduced days of antibiotic use
 - ❖ Effects may be due to antioxidant activity
- There is no evidence to support aerosol administration

Dornase Alfa (Pulmozyme)

- Reduces viscosity of purulent secretions
- May contribute to increased longevity in CF patients
- Not recommended for COPD or bronchiectasis
- Several cases reporting direct instillation for mucus plugging with resolution of atelectasis

See links below for abstract on Pulmozyme & bronchiectasis

Hypertonic Saline Aerosol

- Action: hyperosmolarity causes airway cells to secrete H₂O
- Nebulized 3% - 7% saline QID
- Increases mucus clearance
- May improve pulmonary function
- Effective for sputum induction
- Need trials comparing hypertonic saline with alfa dornase - saline is much less costly

FYI see links below for meta-analysis on hypertonic saline for CF

Surfactant

- Theoretically, decreases adhesion of mucus to airways
- Surfactant abnormality may play a role in generation of COPD
- One trial (1997) - aerosol surfactant improved pulmonary function & mucus clearance for chronic bronchitis
- Need more research

Potential Mucokinetics

- Mannitol dry powder: mucokinesis
- Tyloxapol (formerly Alevaire): antioxidant, detergent
- Nacystelyn: antioxidant, mucokinetic
- Heparin: mucokinesis for CF
- Denufosal tetrasodium: hydrates mucus, improves clearance for CF patients

Summary

- Long-acting beta-agonists may increase mucus clearance
- Bland aerosols & NaHCO₃: no confirmed mucokinetic effects
- Oral mucokinetics, e.g. acetylcysteine: benefits in chronic bronchitis (antioxidant)
- Aerosolized alfa dornase: effective for cystic fibrosis
- Aerosolized hypertonic saline: effective for cystic fibrosis

Nonpharmacologic Mucokinesis

Bronchial Hygiene Physical Therapy

- Components
 - ❖ Percussion
 - ❖ Postural drainage
 - ❖ Vibration
 - ❖ Shaking

Bronchial Hygiene Physical Therapy

- Application as routine for COPD, bronchiectasis & chronic bronchitis
 - ❖ Research has been low-quality
 - ❖ Increases sputum production
 - ❖ No effects on pulmonary function
 - ❖ No evidence either way
- Application for exacerbations of COPD & chronic bronchitis: no evidence

Bronchial Hygiene Physical Therapy

- Application as routine for cystic fibrosis
 - ❖ Some form of BHPT is an accepted standard
 - ❖ Trials with subjects getting no mucokinetic support would be unethical
 - ❖ Research with CF involves comparison of methods
 - ❖ Mechanical percussion is as effective as manual percussion

Cough

- For patients with compromised mucociliary transport, cough is the most effective & important mucokinetic method
- Cough is compromised by
 - ❖ Neuromuscular weakness
 - ❖ Obstructive disease: forced expiration collapses airways (dynamic compression)

FYI see links below to download RC article on FET, cough

Directed Cough

- Directed cough: a deliberate cough maneuver that is taught, supervised, & monitored
- Examples: forced expiratory technique (FET, or huff cough) & manually assisted cough

FYI see links below to AARC clinical practice guideline on directed cough

Directed Cough

- Forced expiratory technique (FET)
 - ❖ Slow diaphragmatic breaths followed by glottis-open huffs at low-to-mid lung volumes
 - ❖ Produce higher flow than maximum forced expiration
 - ❖ Especially useful for patients with obstructive disease

Directed Cough

- Active cycle of breathing: breathing control exercises with FET
 - ❖ Relaxed, normal breathing
 - ❖ Four deep breaths
 - ❖ Relaxed, normal breathing
 - ❖ Deep breaths
 - ❖ Relaxed normal breathing
 - ❖ Low lung volume huffs
 - ❖ High lung volume huffs

Autogenic Drainage

- Controlled breathing at increasing lung volumes
 - ❖ Slow, nasal breathing
 - ❖ 10 - 20 low volume breaths with 3 sec hold
 - ❖ 10 - 20 high volume breaths with 3 sec hold
 - ❖ Huff coughs

Autogenic Drainage

- Especially applicable to CF patients
- At least as effective as BHPT, active cycle of breathing, PEP
- Difficult to learn

Cough Assistance

- Manual cough assistance: tussive squeeze, abdominal thrust
- In/exsufflator: indicated for MEP < 60 cm H₂O
 - ❖ Positive pressure for inflation
 - ❖ Negative pressure for increased expiratory (cough) flow
 - ❖ Usual pressures 40 to -40 cm H₂O
 - ❖ May reverse atelectasis
 - ❖ Improves symptoms & SPO₂

In/exsufflator - Cough Assistance



Image Courtesy of
Philips Respironics

FYI see links below to view Emerson CoughAssist™ web page

Positive Expiratory Pressure PEP

- PEP – CPAP with mouthpiece or mask
- Can administer with small-volume nebulizer treatment
- Effective for cystic fibrosis; not for COPD (see abstract for evidence)
- Patients prefer over BHBT

See links below to see TheraPEP® and
an abstract on PEP therapy and COPD

Vibratory PEP

- Oscillations in airways produced by passive exhalation, with positive end-expiratory pressure
- Devices - equivalent performance
 - ❖ Flutter™: gravity-dependent
 - ❖ Acapella™: not gravity-dependent
- Effective for mucus clearance
- May be effective for atelectasis

Up next: Video of Flutter device (1 min)

Vibratory PEP

- Two models: > 15 L/min, < 15 L/min
- Can administer via
 - ❖ Mouthpiece
 - ❖ Mask
 - ❖ Manual resuscitator
- Can administer with small-volume nebulizer treatment
- Adjustable, but no measure of PEP level

See links below to view Smith-Portex Acapella™ device

Vibratory PEP (Acapella™)

- Recommended regimen
 - ❖ 10 - 20 breaths/cycle
 - ❖ Followed by directed coughs to raise mucus
 - ❖ Repeat cycles for 10 - 20 min up to QID
- Author's preference: many patients require a mask for effective treatment

High-Frequency Oscillation/Percussion

- Approaches
 - ❖ Internal airway oscillation/percussion
 - ❖ External chest oscillation/percussion

Intrapulmonary Percussive Devices

- Vortran PercussiveNeb™
- Percussionaire devices (Dr. Forrest Bird)
 - ❖ IPV 1C™: institutional
 - ❖ Impulsator™: institutional & home

See links below to view PercussiveNeb™ brochure & picture & to view Impulsator™

Intrapulmonary Percussive Devices

- Operation: short inspiratory flow pulses to airways that may work by
 - ❖ Causing radial displacement of airways, pulsing gas to distal side of secretions
 - ❖ Generating high-frequency 'minicoughs' - expiratory oscillations
 - ❖ Mucolysis, due to resonating frequency response
 - ❖ Increased ciliary activity

External Oscillation/Percussion

- High-frequency chest wall oscillation/compression (HFCWO)
 - ❖ The Vest™: home & institutional models
 - ❖ SmartVest™: programmable

See links below to view The Vest™ acute care system
& to view The Smart Vest™ System

Vest Device Operation

- Vest on chest inflated/deflated at adjustable pressure & frequency
 - ❖ 5 - 20 cm H₂O
 - ❖ 2 - 25 Hz
- Oscillates chest
 - ❖ 'Mini-coughs'
 - ❖ Resonating frequency may cause mucolysis

High-Frequency Chest Wall Oscillation

- Hayek RTX™
 - ❖ Also operates in physiological frequency ranges as a cuirass ventilator (see neuromuscular conditions lesson)

Hayek RTX™

- Biphasic: inspiratory & expiratory pressures
 - ❖ Frequency up to 17 Hz
 - ❖ Pressures -70 cm H₂O to +70 cm H₂O
- Oscillations for secretion mode
 - ❖ Vibration phase: high f, low P
 - ❖ Cough phase: low f, higher P

See links below to view Hayek™ ventilator

Evidence for Effectiveness

- Trials are mostly small, crossover trials - quality of evidence?
- These techniques seem to be at least as good as conventional BHPT (depends on who's doing the BHPT)
- Clinical trial (McIlwayne, 2013)
 - ❖ Compared HFCWO vs. PEP
 - ❖ Results favor PEP over HFCWO

Evidence for Effectiveness

- Considerations
 - ❖ Costs: capital, personnel, & training
 - ❖ Portability - home use
 - ❖ Patient capability - self-administration
 - ❖ Patient tolerance
 - ❖ Patient preference → adherence

Dymedso Frequencer™

- Acoustic/mechanical device
- Invented by a cystic fibrosis patient

Transducer



Control Unit

Image courtesy of Dymedso

FYI see links below to view Dymedso Frequencer™

Dymedso Frequencer™

- Operation: mechanical & acoustical stimulation over chest at 30 - 70 Hz
- Agitation by mechanical & acoustical waves causes mucolysis
- Controls adjusted by patient sensation
 - ❖ Frequency
 - ❖ Volume

Dymedso Frequencer™

- Evidence for effectiveness
 - ❖ One clinical trial
 - 22 CF patients
 - Non-randomized
 - Outcome measure: sputum weight
 - More sputum with Frequencer™

Kinetic Bed Therapy

- Intensive care beds with additional capabilities
 - ❖ Rotation
 - ❖ Postural drainage
 - ❖ Percussion
- Rationale: mobilize secretions to prevent ventilator-associated pneumonia & atelectasis

Kinetic Bed Therapy

- Evidence of effectiveness for kinetic beds for mechanically ventilated patients
 - ❖ May compromise hemodynamics - some patients do not tolerate
 - ❖ Clinical trials found mixed results
 - ❖ Meta-analysis concluded
 - Possible reduction in pneumonia
 - No effect on mortality
 - No effect on duration of ventilation
 - No effect on hospital stay

Fiberoptic Bronchoscopy

- Advantage: direct visualization
- Disadvantages
 - ❖ Expense
 - ❖ Invasiveness
- Not indicated for generalized secretion removal
- Indicated for lobar or segmental atelectasis due to mucus plug or foreign body (kids)

Ventilation Patterns

- Ventilator settings influence mucokinesis
 - ❖ Increased inspiratory flow moves mucus deeper
 - ❖ Increased expiratory flow moves mucus cephalad
 - ❖ Increased expiratory time moves mucus cephalad
 - ❖ Auto-PEEP can work either way
- Authors do not advocate clinical application of findings

Summary & Review

- Bronchial hygiene physical therapy
 - ❖ Standard for CF, bronchiectasis
 - ❖ No support for routine application to COPD
- Cough
 - ❖ Becomes primary mucokinetic with impaired mucociliary clearance
 - ❖ Compromised by neuromuscular ds, COPD

Summary & Review

- Directed cough: taught, supervised cough
 - ❖ FET
 - ❖ Active cycle of breathing
- Autogenic drainage, esp. for CF
- Cough assistance: manual & mechanical
- PEP
- Vibratory PEP

Summary & Review

- Intrapulmonary percussive devices
 - ❖ Pulses to airways & mini-coughs
 - ❖ Devices
 - Vortran PercussiveNeb™
 - IPV; Impulsator™ (Forrest Bird)
- External oscillators/percussors
 - ❖ The Vest™
 - ❖ SmartVest™
 - ❖ Hayek RTX™ cuirass

Summary & Review

- Frequencer™ acoustic/mechanical vibrations
- Kinetic bed therapy
- Fiberoptic bronchoscopy
- Ventilation patterns

Therapy for Atelectasis

Atelectasis Primary Types

- **Obstructive atelectasis, AKA absorption atelectasis**
 - ❖ Most common
 - ❖ Mechanism: airway obstructed & distal gas is absorbed
 - ❖ Obstructions
 - Mucus plugs
 - Foreign body - aspiration
 - Tumor - intraluminal or extraluminal

Atelectasis Primary Types

- **Obstructive atelectasis**
 - ❖ Worsened by high FiO_2 - O_2 is absorbed
 - ❖ Lessened by collateral ventilation - augmented by end-expiratory pressure

Atelectasis Types & Causes

- **Non-obstructive**
 - ❖ Passive atelectasis
 - Pleural separation - pleural effusion
 - Shallow breathing - healthy persons develop atelectasis with shallow breathing, as with TV watching
 - ❖ Compression atelectasis
 - Volume occupying lesions
 - Abdominal distension

Atelectasis Types & Causes

- **Non-obstructive**
 - ❖ Adhesive atelectasis
 - Surfactant deficiency, e.g. RDS, ARDS
 - Shallow breathing
 - Inhalation injury, e.g. smoke
 - Cardiopulmonary bypass
 - ❖ Gravity-dependent atelectasis - due to gravity-dependent volume changes in alveoli

Risk Factors

- **Patient factors**
 - ❖ Current smoking
 - ❖ COPD
 - ❖ Ischemic heart disease
 - ❖ Obesity - high risk & persistence
 - ❖ Hx of stroke
 - ❖ Shallow breathing
 - ❖ Watching television - decreases sigh rates (sad movies?)

Risk Factors

- **Nosocomial factors**
 - ❖ Anesthesia
 - ❖ High FiO_2 - O_2 absorbed
 - ❖ Cardiopulmonary bypass

Complications

- Atelectasis after upper abdominal & thoracic surgery is common
- Postoperative atelectasis does not commonly cause significant morbidity
- Hypoxemia - most common
- Pneumonia - rarely a result of postoperative atelectasis
- Fever - NOT

Prevention of Atelectasis - NOT

- Interventions that do NOT prevent postoperative atelectasis
 - ❖ Incentive spirometry
 - ❖ Bronchial hygiene physical therapy
 - ❖ Kinetic beds
- Routine application of these measures to prevent postoperative complications is not justified by research findings

See links below for abstract on incentive spirometry evidence

Prevention of Atelectasis

- Interventions that may help prevent postoperative atelectasis
 - ❖ Avoiding high FIO₂ during & after surgery - increasing FIO₂ to extubate increases risk for postoperative atelectasis
 - ❖ PEEP during surgery, especially for obese patients
 - ❖ Ambulation

Prevention of Atelectasis

- Interventions that may help prevent postoperative atelectasis
 - ❖ PEP, CPAP after surgery - good evidence in support
 - Thoracoabdominal aneurysm surgery - continuous NCPAP @ 10 cm H₂O for 12 - 24H
 - PEP or CPAP via face mask 30 breaths Q1H x 3D (pressure?)
 - Meta-analysis supports

FYI see links below for article on nCPAP for postop patients

Prevention of Atelectasis

- Interventions that may help prevent postoperative atelectasis
 - ❖ Deep breathing exercises? NOT
 - 2005 study - deep breathing was with 10 cm PEP
 - ❖ Cough assistance - patients with impaired cough
 - ❖ Vibratory PEP?

Treatment of Atelectasis

- Obstructive atelectasis
 - ❖ Bronchial hygiene physical therapy - first choice for acute atelectasis
 - ❖ Bronchoscopy
 - Foreign body aspiration
 - Acute, extensive atelectasis
 - ❖ Alfa dornase (Pulmozyme) nebulized & instilled - for non-CF pediatric patients
 - ❖ Cough assistance?

Treatment of Atelectasis

- > Non-obstructive atelectasis
 - ❖ Intrapulmonary percussive ventilation
 - 15 min BID via face mask - pediatric patients
 - Superimposed on CMV for obese patients
 - ❖ Vibratory PEP?
 - ❖ Ambulation

Treatment of Atelectasis

- > Non-obstructive atelectasis
 - ❖ CPAP, PEP
 - ❖ Noninvasive pressure support (BiPAP) - face mask
 - May be better than CPAP
 - PEEP 5 cm H₂O
 - PS for TV = 8 - 10 mL/kg
 - 30 min QID
 - Improved radiological atelectasis score over CPAP

Bottom Line (My Opinion)

- > In most instances, atelectasis happens (like the bumper sticker)
- > For most patients, ambulation is all that's needed to prevent & treat atelectasis
- > Incentive spirometry is a waste of time, money & environmental resources (plastic, dump space)

Bottom Line (My Opinion)

- > Patients at risk may benefit from preventative measures
 - ❖ Morbidly obese
 - ❖ Excessive, tenacious secretions
 - ❖ Prolonged procedures, especially on CP bypass
 - ❖ Compromised cough
 - Peak cough flow < 160 L/min (adults)
 - MEP < 45 cm H₂O

Bottom Line (My Opinion)

- > Preventative measures
 - ❖ Cough assistance for weak cough
 - ❖ CPAP, BiPAP, vibratory PEP
 - ❖ Most patients need mask therapy
 - ❖ End-expiratory pressure should be measured: ≥ 10 cm H₂O
 - ❖ Duration & frequency must be adequate?
 - Continuous nCPAP or BiPAP
 - 30 breaths Q1H

Bottom Line (My Opinion)

- > Atelectasis is common - only treat for acute, complicated cases
 - ❖ Clinical signs of respiratory distress
 - ❖ Moderate-severe hypoxemia
 - ❖ Segmental, lobar involvement

Bottom Line (My Opinion)

- Treatment measures
 - ❖ CPAP, PEP, BiPAP, vibratory PEP - by mask
 - ❖ Bronchial hygiene physical therapy
 - ❖ Cough assistance
 - Manual
 - Mechanical - CoughAssist™
 - ❖ Intrapulmonary percussive ventilation - mask or with ventilator
 - ❖ Fiberoptic bronchoscopy - lobar, from plugs

Summary & Review

- Atelectasis
 - ❖ Types
 - Obstructive
 - Non-obstructive: adhesive, passive, etc.
 - ❖ Risk factors - patient & nosocomial
 - ❖ Complications
 - Hypoxemia
 - Pneumonia - rare
 - Fever - NOT

Summary & Review

- Prevention of atelectasis
 - ❖ NOT
 - BHPT
 - Incentive spirometry
 - ❖ Maybe
 - PEP, CPAP, vibratory PEP
 - Cough assistance

Summary & Review

- Treatment of atelectasis
 - ❖ Obstructive
 - BHPT
 - Bronchoscopy
 - ❖ Non-obstructive
 - Intermittent percussive ventilation
 - PEP, CPAP, vibratory PEP
 - BiPAP

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