Hyperinflation Therapy

CRC 330
Cardiorespiratory Care
University of South Alabama
Hyperinflation Therapy

- Atelectasis
- Incentive Spirometry
- Intermittent positive pressure breathing
- Positive Expiratory Pressure
- Metatherapy/Metaneb
- Intrapulmonary Percussive Ventilation
- Continuous Positive Airway Pressure
Atelectasis

- Greek for “without air”
- Susceptible patients
  - Postoperative or debilitated patients
  - Patients who won’t or can’t take a deep breath
  - Patients with retained secretions or mucus plugging
Gas Absorption Atelectasis

- Obstruction of the bronchus by tumor, mucus, foreign body, or contralateral ETT
- Oxygen distal to the obstruction diffuses into the pulmonary blood
- Alveoli shrink and collapse
- More pronounced when the FiO₂ is high
- Therapy is directed at the cause
Compression Atelectasis

- Failure of ability to intermittently stretch alveoli by deep breathing, sighing, or yawning
- Alveoli shrink, and eventually collapse
- Most often seen in patients postoperatively
- Repositioning, deep breathing, IS, IPPB
- Tailor therapy to patient’s abilities
Who needs lung expansion therapy?

- Neuromuscular disease (myasthenia gravis, Guillian-Barre syndrome, muscular dystrophy)
- Heavy sedation (narcotics, barbiturates, anesthetics)
- Upper abdominal or thoracic surgery (risk increases closer to the diaphragm)
- Spinal cord injury (due to trauma)
- Being bedridden or immobile (stroke, Alzheimer’s disease, coma)
- Abnormal preoperative spirometry
The particular risk for postoperative patients

- General anesthesia,
- Smoking and abnormal spirometry,
- Rapid shallow breathing due to pain,
- Transient decrease in surfactant production all lead to decreased FRC
- Dependent lung segments, decreased V/Q, hypoxemia
The particular risk for postoperative patients

- Splinting and decreased Vt
- Impaired cough and mucociliary escalator leads to inspissation and plugging
- Hyperinflation therapy
  - Improves tracheobronchial hygiene
  - Facilitates cough
  - Prevents atelectasis
Symptoms of atelectasis

- Rapid shallow breathing
- Increased tactile fremitus
- Dullness to percussion
- Fine, late inspiratory crackles, bronchial or decreased breath sounds
- Abnormal voice sounds
- Tachycardia and fever
- Hypoxemia
Symptoms of atelectasis: CXR

- Increased opacity
- Plate atelectasis
- Fissure displacement
- Crowding of pulmonary vasculature
- Air bronchograms
- Elevation of adjacent diaphragm
- Narrowed rib interspaces
- Mediastinal/tracheal shift
- Compensatory hyperexpansion of surrounding lung
Physiologic Basis of Hyperinflation Therapy

- Facilitate lung expansion by increasing the transpulmonary pressure gradient ($P_L$)
- $P_L = P_{alv} - P_{pl}$
- Decrease the $P_{pl}$ (IS) or increase the $P_{alv}$ (IPPB, PEP, CPAP, IPV)
- Decreasing the $P_{pl}$ is more physiologic because it's the same as normal breathing
Incentive Spirometry

- Inspiration of a predetermined volume or flow, for as long as the patient can, followed by an inspiratory pause of > 3 sec
  - from resting level up to inspiratory capacity
  - mimics natural sigh or yawn
  - sighing is the natural method to avoid atelectasis, which is lost in the postoperative period
- Increases the $P_L$ by decreasing the $P_{pl}$ below that normally achieved
Limitations of Method

- Use of IS to prevent PPC is controversial
- Used alone, may not prevent or treat PPC
- Most effective when combined with early mobilization, deep breathing, cough and anlagesia
- Benefit in CABG, bariatric surgery, esophagectomy, and N-M disease is not convincing

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Goals/Outcomes of Incentive Spirometry

- Absence of or improvement in signs of atelectasis
- Improved VS
- Normalization of BS
- Absence of crackles
- Improved radiograph
- Improved \( \text{SpO}_2, \text{PaO}_2 \) and \( \text{PaCO}_2 \)
- Restoration of preoperative volumes
- Improved inspiratory muscle performance
Incentive Spirometry

**Indications**

- Presence of atelectasis or conditions predisposing to atelectasis
  - Abdominal or thoracic surgery, prolonged bed rest, surgery of patients with COPD, lack of pain control, presence of thoracic or abdominal binders, acute chest syndrome in patients with SCD, CABG
  - Restrictive lung defect associated with quadriplegia or dysfunctional diaphragm
Incentive Spirometry

- **Hazards**
  - correctly performed IS has few, if any
  - don't interrupt oxygen therapy
  - don't allow patient to perform too fast
    - Dizziness, respiratory alkalosis
  - Discomfort secondary to inadequate pain control
  - Exacerbation of bronchospasm
  - Fatigue
  - Pain
Incentive Spirometry

- Indirectly indicate volume based on flow through a fixed orifice
- Not precisely accurate, but adequate
- Indicator set to goal
- Goal = volume from included nomogram; > 15 mL/kg IBW
Incentive Spirometry

- Volume oriented spirometer
- Bellows displacement
- Actually measures volume
- Usually larger
- May be more expensive
Incentive Spirometry

**Planning**
- identify explicit goals based on patient ability
- baseline assessment should include all patients scheduled for upper abdominal and thoracic surgery
- determine preop IC as postop goal, using the chart included with the IS
- if postop VC is < 12-15 cc/kg, or the IC is < 1/3 predicted, consider IPPB
- if the patient is uncooperative, obtunded, unconscious, IS is not possible: use IPPB, NIV, or CPAP
Incentive Spirometry

- Implementation
  - goal should be obtainable, but require moderate effort (no pain no gain)
  - inhale slowly and deeply
  - breath-hold for 5 sec
  - may be necessary to rest 30-60 sec to avoid hyperventilation
  - 10 maneuvers/1-2 hours; this mimics the normal sigh
Incentive Spirometry

- Follow up/monitoring
  - Frequency of sessions
  - Number of breaths/session
  - Volume goal achieved
  - Breath hold maintained
  - Effort
  - Periodic observation of compliance
  - Keep IS within reach
  - VS/BS
Intermittent Positive Pressure Breathing (IPPB)

- Application of inspiratory positive pressure
- With aerosol therapy (usually a bronchodilator)
- Spontaneously-breathing patient, short time (15-20 min)
- Q1 hour to 3-4x daily
- A history shrouded in controversy
- Increases $P_L$ and therefore lung volume by increasing $P_{alv}$
- Not the first-choice when other therapy is cheaper
- Can be volume or pressure oriented
Indications for IPPB

- Clinically diagnosed atelectasis not responsive to other therapies
- Patients at high risk for atelectasis
- Delivery of aerosol if SVN therapy is ineffective
- Inability to clear secretions
- Need to deliver medications
IPPB Hazards

- Increased airway resistance
- Pulmonary barotrauma
- Nosocomial infection
- Respiratory alkalemia
- Hyperoxia
- Decreased venous return
- Gastric distention
- Air trapping
- Psychological dependence
IPPB: Contraindications

- Tension pneumothorax
- ICP > 15 mmHg
- Hemodynamic instability
- Active hemoptysis
- Tracheoesophageal fistula
- Recent esophageal, facial, skull, or oral surgery
- Active, untreated TB
- Radiographic evidence of blebs
- Singulitus
- Air swallowing, nausea
IPPB ventilator: Bird Mark 7

- Pneumatically powered
- Pressure controlled
- Pressure triggered
- Pressure cycled
- Flow or pressure limited
- Must measure exhaled volumes
Mark 7
Mark 7A
Figure 7-17 Structure of a Bird Mark 7. (Modified from Viasys Healthcare, Critical Care Division, Palm Springs, Calif.)
Figure 7-18 A, Inhalation. B, Exhalation. (Modified from Viasys Healthcare, Critical Care Division, Palm Springs, Calif.)
Figure 7-20 Air-Mix control for Bird Mark 7. The schematics show typical patterns for flow and pressure during Air-Mix (left) and 100% oxygen (right). (Modified from Viasys Healthcare, Critical Care Division, Palm Springs, Calif.)
IPPB: Administration

- Planning
  - Determine need and desired outcomes
    - Must be measurable
    - 1/3 predicted IC (1/3x50 mL/kg)
    - Improved radiograph
    - Improved BS
    - Decreased f
  - Simpler method effective?
- Baseline evaluation
  - VS, appearance and sensorium, breathing pattern, auscultation
IPPB: Administration

- Implementation
  - Equipment preparation
    - Assure correct function of the ventilator and circuit
  - Patient orientation
    - Explain purpose
    - Why ordered, what treatment does, how it will feel, outcomes
    - Simulated demonstration with a test lung
  - Patient positioning
    - upright
IPPB Administration

- Initial application
  - Nose clip or lip seal may be necessary
  - Insert mouthpiece beyond lips, tight seal
  - Mask for alert and cooperative patients only, who leak with a mouthpiece
  - Sensitivity: -1 to -2 cm H₂O
  - Pressure 10-15 cm H₂O, measure volume
  - Mid-flow range
  - 6 bpm, I:E of 1:3 to 1:4
IPPB Administration

- Adjusting parameters
  - Adjust pressure to achieve volume goal
    (70% of predicted IC or 10-15 mL/kg)
  - Patient should breathe actively
IPPB Monitoring and Troubleshooting

- Machine performance
  - Negative pressure swings at initiation of inspiration
  - Ti too long or short
  - Linked tubing or mouthpiece obstruction
  - Leaks
IPPB Monitoring and Troubleshooting

- Patient Response
  - Breathing rate and expiratory volume
  - VS and BS
  - Sputum characteristics
  - Sensorium
  - ICP
  - Radiograph
  - Subjective response
IPPB: Infection control

- New circuit every day
- Standard precautions
- Assure cleanliness of nebulizer, don't rinse in tap water
Airway Pressure Adjuncts
Primarily for Treatment of Atelectasis and Secondarily for Retained Secretions

- CPAP
- PEP
- Metatherapy
- IPV
CPAP

- Patient breathes from a pressurized circuit against a threshold resistor
- 5-20 cm H$_2$O
- Gas flow is high enough to keep pressure positive throughout I and E
- Pressure is increased until PaO$_2$ responds, then FiO$_2$ is decreased
- Treatments or continuous
CPAP Circuit
PEP

- Patient exhales against a fixed orifice resistor
- 10-20 cmH₂O
- Done as a treatment
- Includes Flutter and Acapella
Vibratory PEP - Acapella
Airway Pressure Adjuncts

- **Indications**
  - reduce air trapping by providing an opposing pressure, splinting the airways open
  - aid in mobilization of retained secretions
  - prevent/reverse atelectasis
  - optimize delivery of bronchodilators
Airway Pressure Adjuncts

- Contraindications
  - patients unable to tolerate the increased WOB
  - increased ICP
  - hemodynamic instability
  - recent oral, facial or skull surgery or trauma
  - acute sinusitis
Airway Pressure Adjuncts

- Hazards/complications
  - increased WOB
  - increased ICP
  - cardiovascular compromise
  - air swallowing
  - claustrophobia
  - mask trauma
  - pulmonary barotrauma
  - system leakage
Airway Pressure Adjuncts

- **Assessment of need**
  - sputum retention not responsive to spontaneous or directed coughing
  - decreased/adventitious breath sounds
  - tachypnea, tachycardia
  - atelectasis, mucous plugging, infiltrates on CXR
  - hypoxemia, desaturation
Airway Pressure Adjuncts

- Assessment of outcome
  - change in sputum production: if it does not increase with PEP, then PEP is not indicated
  - breath sounds should clear
  - vital signs should improve
  - radiograph should improve
  - ABGs or sat should improve
Airway Pressure Adjuncts

- **Equipment**
  - PEP: PEP device with fixed orificial resistor and manometer
Airway Pressure Adjuncts

- EZ PAP
- Gas powered PEP system
Airway Pressure Adjuncts

- Monitoring
  - patient’s subjective response to therapy
  - pulse rate and ECG
  - breathing pattern and rate
  - sputum production
  - skin color
  - breath sounds
  - blood pressure
  - pulse oximetry/ABGs
  - ICP if applicable
Airway Pressure Adjuncts

- **Frequency**
  - in the ICU, q 1-6 hours, especially for CPAP to treat atelectasis
  - otherwise 2-4 times daily depending on patient response
  - reevaluate every 72 hours
Metatherapy/Metaneb
Metaneb/Metatherapy

- Therapeutic objective
  - Enhanced secretion removal
  - Prevent or resolve patchy atelectasis

- Three modes
  - Aerosol
  - Continuous high frequency oscillation
  - Continuous positive expiratory pressure
Continuous High Flow Oscillation (CHFO)

- Pneumatic CPT
- Adds aerosol medication
- Increases mean Paw to maintain airway caliber, prevent premature closure, expand collapsed lung regions
- Creates a pressure gradient to accelerate expiratory flow to move secretions
- Hyperinflates through PEP to enhance deep breathing
Continuous Positive Expiratory Pressure (CPEP)

- CPAP created by a flow and expiratory resistance
- Prevents or reverses atelectasis
- Aids in mobilization of retained secretions
- Reduces air trapping
Metaneb procedure

- **2 ½ minutes**
  - CPEP with Aerosol
  - Lung Expansion

- **2 ½ minutes**
  - CHFO with Aerosol
  - Secretion Clearance

- **2 ½ minutes**
  - CPEP with Aerosol
  - Lung Expansion

- **2 ½ minutes**
  - CHFO with Aerosol
  - Secretion Clearance
Metaneb procedure

- May also be attached to the inspiratory limb of the ventilator circuit
- Requires adjustment of ventilator parameters
- May also be attached to a tracheostomy tube
- Follow recommended procedure
Metaneb circuit
Assessment of Outcome

- D/C therapy when
  - Secretion clearance is < 5 cc/treatment for 24 hrs.
  - Post-therapy chest examination demonstrates absence of retained secretions
  - Clearing/improvement of breath sounds
Intrapulmonary Percussive Ventilation (IPV)

- IPV ventilator creates a pneumatic oscillation of 100-225 cycles per minute (1.6-3.75 Hz) during inspiration or both inspiration and expiration

- Purpose
  - Oscillation is designed to open atelectatic areas, force air behind mucus obstructions, and promote mucus clearance
IPV

ENDOBRONCHIAL PERCUSSIVE MIXING

STEP INFLATION LUNG VOLUME INCREASING AUTOMATIC CPAP STABILIZER

END INSPIRATORY INTERVAL PASSIVE EXPIRATORY TIDAL EXPULSION OF SECRETIONS

i/e 1:2.5 f=100-300/MIN PERCUSSION 30-40 PSIG

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IPV
IPV Patient Interface
IPV

- Research on this method is scarce
- IPV is as effective as postural drainage and percussion in promoting mucus clearance in cystic fibrosis patients.
- Anecdotal reports are encouraging regarding the treatment of atelectasis where IPV may be more effective than other methods.
Selecting an approach

- Key Factors
  - Meets inclusion criteria
  - Level of alertness
- Recommended techniques for specific conditions/devices
- Example algorithm
Patient meets criteria?

YES

Patient alert?

YES

NO

VC > 15 ml/kg or IC > 33% predicted

NO

PEP therapy with bronchodilator and bronchial hygiene

YES

Problem with excess secretions?

NO

Goal-oriented incentive spirometry

Problem resolution?

NO

Trial of intermittent CPAP

YES

Discontinue therapy

IPPB therapy 10-15 ml/kg