AIRWAY CLEARANCE AND HYPERINFLATION THERAPY IN PEDIATRICS

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AIRWAY CLEARANCE VS. HYPERINFLATION THERAPY

- What is the difference?
- Available therapies
- Indications/contraindications
- Evidence to support their use
- Use of RT driven protocols

SECRETION MANAGEMENT VS. LUNG EXPANSION

- Secretion management
  - Patients unable to clear secretions with cough or suction
  - Atelectasis on CXR with suspected retained secretions
  - Evidence of history of mucus plugging

- Volume expansion
  - Patients at risk for or with existing atelectasis unrelated to secretions

AVAILABLE THERAPIES

- Manual Methodologies
  - Active cycle breathing techniques (ACBT), Autogenic drainage (AD), Chest physiotherapy (CPT), Forced expiration technique (FET)
- High Frequency Chest Wall Compression/High Frequency Chest Wall Oscillation (HFCWC/HFCWO)
  - Intrapulmonary Percussive Ventilation, MetaNeb, Volara, Vest/Wrap, Flutter
- Mechanical Insufflation-Exsufflation (MI-E)
  - Cough assist
- Other Positive Airway Pressure (PAP) Adjuncts
  - PEP, Combination, CPAP/EPAP/PEEP
- Other Lung Expansion/Hyperinflation Techniques
  - Incentive Spirometry (IS), Intermittent Positive Pressure Breathing (IPPB)

HFCWC APPLIED TO NATURAL OR ARTIFICIAL AIRWAY

- Absolute Contraindications
  - Untreated pneumothorax

- Relative Contraindications
  - Active, untreated TB; TEF/recent esophageal surgery; pulmonary hemorrhage; increased ICP; hemodynamic instability; recent orofacial surgery; nausea/vomiting; gastric distension; radiologic evidence of bleb/bullae

HFCWO APPLIED EXTERNALLY TO THE CHEST WALL

- Relative Contraindications
  - Recent skin grafts or flaps on the thorax; burns, open wounds and/or skin infections of the thorax; presence of endotracheal tube; pulmonary hemorrhage; fresh tracheostomy (within 7 days) or other surgical considerations

MI-E

- Absolute Contraindications
  - Untreated pneumothorax
- Relative Contraindications
  - Active, untreated TB; presence of increased ICP or intracranial aneurysm; acute unstable head, neck, or spine surgery; pulmonary hemorrhage; hemodynamic instability

PAP ADJUNCTS

- Relative Contraindications
  - Presence of increased ICP; hemodynamic instability; untreated pneumothorax; recent orofacial surgery or trauma; recent esophageal surgery; epistaxis; tympanic membrane rupture; nausea/vomiting

SHOW ME THE EVIDENCE!

WHAT DOES THE LITERATURE SAY?

- AARC Evidence-Based Clinical Practice Guidelines
  - Nonpharmacologic Airway Clearance (2013)
  - Pharmacologic Airway Clearance (2015)
  - Mainly focused on adult care

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HOSPITALS · RESEARCH · FOUNDATION

AARC American Association for Respiratory Care

- One pediatric study published discussing implementation of a RT driven protocol

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AARC Clinical Practice Guideline: Effectiveness of Nonpharmacologic Airway Clearance Therapies in Hospitalized Patients

Shawna L Strickland PhD RRT-NPS AE-C FAARC, Bruce K Rubin MD MEngr MBA FAARC, Gail S Drescher MA RRT, Carl F Haas MLS RRT FAARC, Catherine A O'Malley RRT-NPS, Teresa A Volsko MHHS RRT FAARC, Richard D Branson MSc RRT FAARC, and Dean R Hess PhD RRT FAARC

- Systematic review to evaluate airway clearance therapies (ACT) intended to
  - Improve gas exchange
  - Decrease ventilator days
  - Decrease length of ICU stay
  - Reduce atelectasis/consolidation
  - Improve lung mechanics
- Adult and pediatric patients without Cystic Fibrosis (CF)

THE GUIDELINES

- Evaluated ACBT, CPT, FET, HFCWC, IPV, MI-E, and PEP
- Only low-level is available
- CPT not recommended for uncomplicated pneumonia
- ACT not recommended for patients with adequate cough/ability to mobilize secretions
- MI-E should be implemented in neuromuscular disease (NMD) when peak cough flow < 270 L/min
- Insufficient evidence to support CPT, PEP, IPV, or HFCWC in NMD patients
- IS not recommended for preventative use in postop patients, early mobility encouraged, and ACT not recommended for routine postop care

Strickland et al. AARC Clinical Practice Guideline: Effectiveness of Non-pharmacologic Airway Clearance Therapies in Hospitalized Patients. Respiratory Care 2013, 58 (12), 2187-2193.

AARC Clinical Practice Guideline: Effectiveness of Pharmacologic Airway Clearance Therapies in Hospitalized Patients

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- Systematic review to evaluate use of aerosolized medications to improve airway clearance to
  - Improve gas exchange
  - Decrease ventilator days
  - Decrease length of ICU stay
  - Reduce atelectasis/consolidation
  - Improve lung mechanics
- Adult and pediatric patients without CF

THE GUIDELINES

- Evaluated albuterol, salbutamol, pirbuterol, levalbuterol, salmeterol, formoterol, ipratropium bromide, oxitropium bromide, glycopyrrolate, tiotropium bromide, N-acetylcysteine, dornase alfa, sodium bicarbonate, guaifenesin, mannitol, hypertonic saline, normal saline, inhaled heparin, inhaled heparin + N-acetylcysteine, albuterol + N-acetylcysteine, inhaled tissue plasminogen activator

- Only low-level is available

Strickland et al. AARC Clinical Practice Guideline: Effectiveness of Pharmacologic Airway Clearance Therapies in Hospitalized Patients. Respiratory Care 2015, 60 (7), 1071-1077.

THE GUIDELINES

- Routine use of bronchodilators or N-acetylcysteine to assist in clearing retained airway secretions is not recommended
- Dornase alfa should not be used in non-CF bronchiectasis
- Insufficient evidence to support routine use of aerosolized medications in NMD for airway secretion management or mucolytics and bronchodilators for the treatment of postop atelectasis
- Hypertonic saline is helpful in the CF population; however, its efficacy has not been shown in other patient populations
- Adverse side effects of hypertonic saline include bronchospasm, decreased FEV1, increased vascular permeability, neutrophil adhesion, and gland secretion in normal lung tissue with pulmonary disease despite treatment with albuterol prior to hypertonic administration
- Insufficient evidence to argue for combination albuterol/hypertonic saline as far as safety, stability, and efficacy

Strickland et al. AARC Clinical Practice Guideline: Effectiveness of Pharmacologic Airway Clearance Therapies in Hospitalized Patients. Respiratory Care 2015, 60 (7), 1071-1077.

Implementation of a β-Agonist/Airway Clearance Protocol in a Pediatric ICU

Gary R Lowe MEd RRT-NPS RPFT, J Randy Willis MBA RRT-NPS, Shasha Bai PhD, and Mark J Heulitt MD FAARC

Background: RT Driven protocols have been used for decades with positive impacts on reducing harmful therapy, health-care costs, and length of stay.

Methods: An original beta-agonist/airway clearance pathway was created in a pediatric ICU. A pre/post-implementation survey was conducted of RTs and ordering providers. A retrospective review of outcomes compared pathway to physician-directed care ordering was conducted.

Table 2. Scoring Tool Used With the β-Agonist/Airway Clearance Protocol

Item	Score = 0	Score = 1	Score = 2
History	No underlying pulmonary diagnosis	History of underlying pulmonary disease or premature newborn	History of underlying pulmonary disease with exacerbation; or receiving mechanical ventilation or bi-level ventilation
Gestalt	Alert, responsive	Anxious or fearful; or altered level of consciousness or lethargic	Obtunded or non-responsive; or receiving mechanical ventilation
Cough	None	Present but effective for clearing secretions	Ineffective in clearing secretions, non-existent, persistent, or constant
Surgery (past 14 d)	None; or other than specified for score 1 or score 2	Major spinal surgery, lower extremity surgery; or neurosurgery	Thoracic or upper abdominal surgery; or surgery and history of underlying pulmonary disease
Breathing pattern/work of breathing/activity level	Ribcage/abdominal synchrony or baseline; no retractions; no dyspnea with normal speech; ambulatory or normal activity for age	Moderate dyspnea with 5–8-word sentences; or decreased activity or out of bed with assistance. Mild increase in work of breathing, flaring, retracting, tracheal tug	Ribcage/abdominal asynchrony; moderate to severe work of breathing or dyspnea with <5-word sentences; or concentrates on breathing; immobile and predominantly in supine position; intercostal, suprasternal, or subcostal retractions; sternocleidomastoid muscle or head bobbing; nasal flaring; grunting; intercostal, suprasternal, or subcostal retractions
Breathing frequency	Normal for age	Frequency >10 breaths/min above normal parameters	Frequency >20 breaths/min above normal parameters
Secretions	Normal oral secretions	Significant volume of clear or white secretions	Significant volume of yellow or green secretions
Breath sounds	Clear and equal with good aeration, upper airway congestion only or baseline	End expiratory wheezes; or fine end-inspiratory crackles; or crackles in one segment only	Wheezing throughout expiration; or inspiratory/expiratory wheezing; or early, mid, or continuous inspiratory or expiratory crackles; or crackles in more than one segment; or diminished
Prolonged expiration	None		Moderate-severe
Pulse oximetry	>95% receiving room air; or pulse oximetry not indicated	92–94% receiving room air (does not apply to congenital heart disease patients)	<92% receiving room air; or patient receiving oxygen (does not apply to congenital heart disease patients
Sputum culture (past 14 d)	None; normal flora		Abnormal bacteria or fungus
Chest radiograph	None; or no evidence of hyperexpansion, focal infiltrate, or atelectasis		Hyperexpansion, focal infiltrate, or segmental or lobar atelectasis

Lowe et al. Implementation of a β-Agonist/Airway Clearance Protocol in a Pediatric ICU. Respiratory Care 2017;62(3):259-267.

Table 3. Therapy Frequency Based on β-Agonist/Airway Clearance Protocol Score

RCS	Therapy Frequency	RCS Reevaluation
0–3	Discontinue, as needed, or home regimen	All reevaluations every 24 h on day shift
4–6	12 h	
7–9	8 h	
10–12	6 h	
>13	4 h	

RCS = respiratory care score

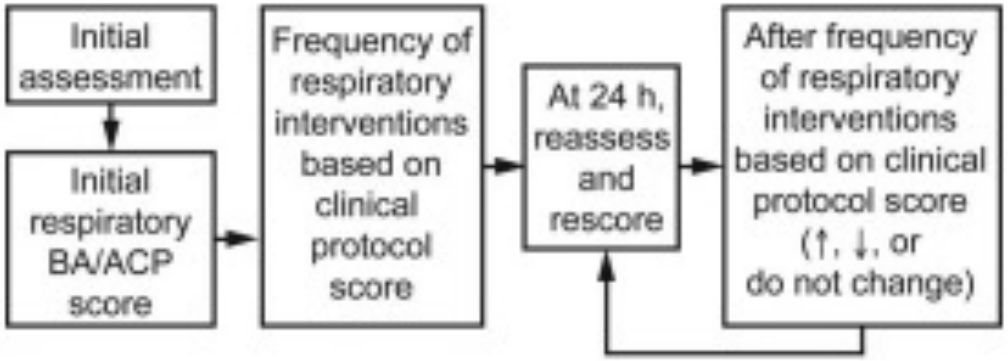

Fig. 1. Intervention flow diagram for the β-agonist/airway clearance protocol (BA/ACP).

Lowe et al. Implementation of a β-Agonist/Airway Clearance Protocol in a Pediatric ICU. Respiratory Care 2017;62(3):259-267.

Results:

- Outcomes in protocol group were statistically and clinically significant
  - Reduction in length of stay by 15.5%
  - Reduction in use of β-agonists by 37%
  - Reduction in use of airway clearance therapies by 21.8%
  - Reduction in ventilator days by 25.2%

- Cost and time savings analysis in protocol group
  - 764.3 hours (0.7 FTE) of RT salary equivalent to $24,000
  - Charges to patients $284,355
  - Reduction of ICU stay by 11% equivalent to $314,844
  - Cost savings in patient charges of 6 months totaled $599,199

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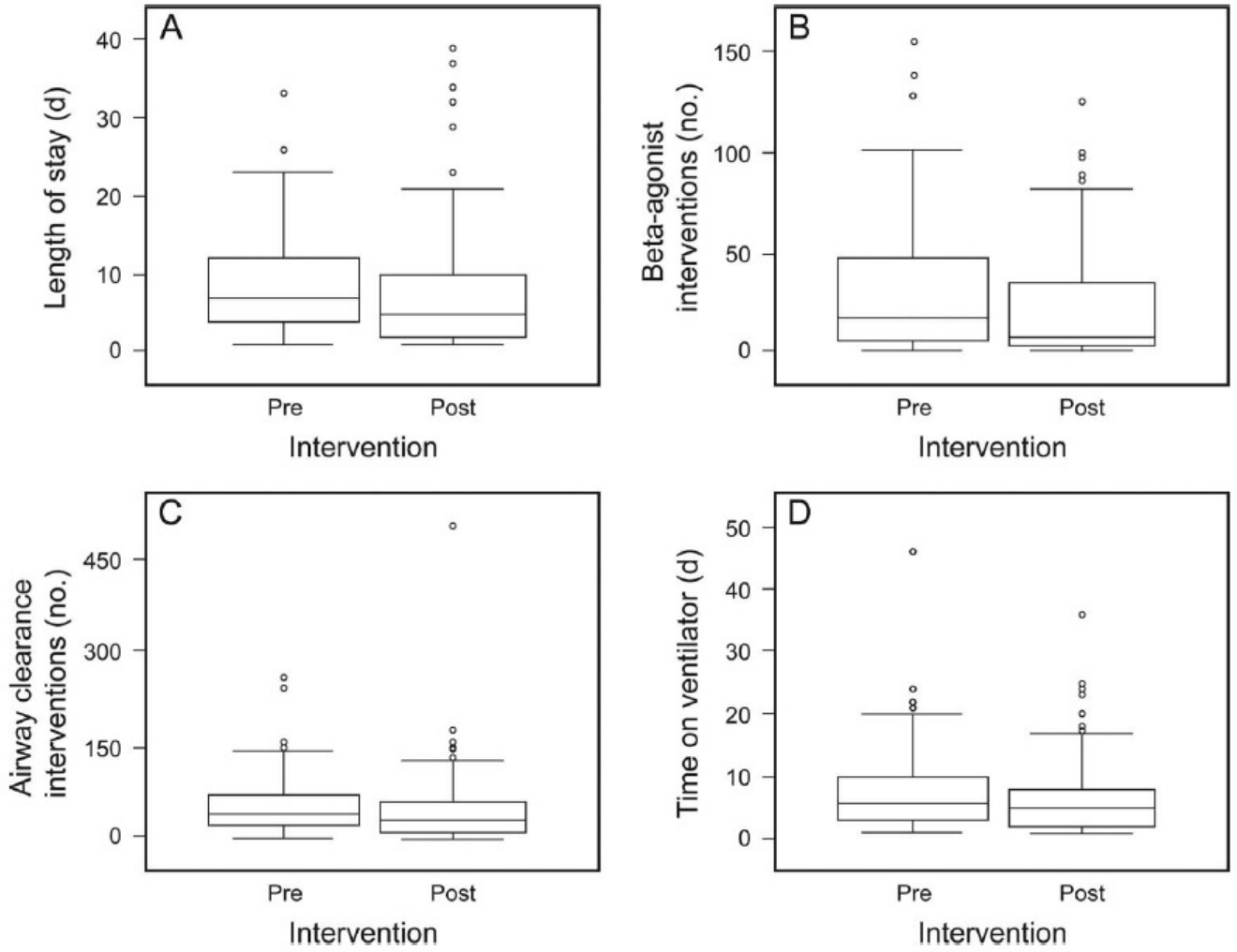

Fig. 2. Comparison of subject outcomes between pre- and post-intervention groups. Boxes show 25th and 75th percentiles, and center lines denote the median. Whiskers represent upper and lower adjacent values, defined as the largest observation that is ≤75th percentile + 1.5 interquartile ranges and the smallest observation that is ≥25th percentile − 1.5 interquartile ranges. Points denote outliers.

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- *Conclusions:* An original beta-agonist/airway clearance pathway reduced patient interventions and improved outcomes in a clinical area where evidence is lacking.

- *Limitations:* Retrospective, single-center, narrow care area, characteristics of pre/post implementation groups

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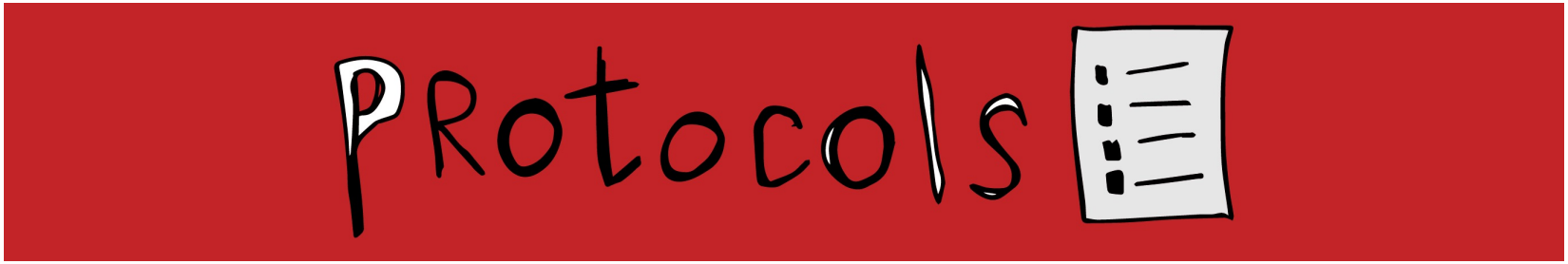
PROTOCOLS & PATHWAYS



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WHAT ARE RT DRIVEN PROTOCOLS?

- Patient care plans created and implemented by RTs
  - Written description of care patient will receive
  - Based on patient interview, physical assessment, review of diagnostic test results, and consideration of treatment modalities available
  - Provide flexibility because they can be modified to the individual patient's needs
  - The main purpose is to standardize decision making
  - Use objective criteria for initiation of respiratory care

RECIPE FOR A PROTOCOL

- Elements of a basic respiratory care protocol may include:
  - Goals of therapy
  - Device, procedure, or medications
  - Method or application
    - Gas source/oxygen concentration
    - Device pressure, volume, and/or flow
    - Frequency of administration and duration of therapy
    - Mechanical ventilation therapy
  - Advanced therapy options
    - Expert consultation
    - Further involvement of the multidisciplinary team

BENEFITS OF RT DRIVEN PROTOCOLS

- Decreases health-care costs
  - Allocation of resources
    - Staff, equipment, medications, processing
  - Delivery of effective, appropriate, consistent therapies
    - Triage of care
- Improves staff morale
  - Elevates status of RTs through clinical contributions
  - Increases value of RTs to multidisciplinary medical team
  - Autonomy within scope of practice
- Improves patient care outcomes
  - Standardized approach to initiation, titration, and discontinuation of therapies
  - Decreased cost without adverse effects
  - Ventilator days, ICU stay, length of admission

HEALTHCARE PROTOCOL IMPLEMENTATION

- Step-wise Approach
  - Step 1: Facility preparedness – readiness for action
  - Step 2: Baseline evaluation – establishing knowledge of the current situation
  - Step 3: Implementation – introducing the improvement activities
  - Step 4: Follow-up evaluation – evaluating the implementation impact
  - Step 5: Ongoing planning & review cycle – developing a plan for the next 5 years

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RT DRIVEN PROTOCOL DEVELOPMENT

- Process begins when patient enters the healthcare setting
- Following initial assessment and verification of problem or diagnosis
  - An order for respiratory care may be written
  - Medical records are reviewed/patient interviewed
  - Physical assessment and bedside measurements performed
  - Appropriate care selected based on patient's condition
  - Care is delivered and patient is monitored
  - Protocol reevaluated based on patient's response
- The goal of the respiratory care protocol is to optimize match between care needed and treatment options available

WHAT ARE PATHWAYS?

- A pathway describes a probable sequence of events during a patient's course of care
  - Outlines tests, procedures, and education during a length of stay
- Define the optimal sequence of key interventions performed by every discipline involved in patient care
- To develop a pathway, all activities to be accomplished during a process are identified and timed
- Designed to minimize delays using the least amount of resources
- Implemented to provide a multidisciplinary approach, to coordinate care, and incorporate the entire team in providing the best healthcare

SO WHAT'S NEXT?

OUR INSTITUTIONAL EXPERIENCE

- Over prescription of airway clearance therapies
  - Pharmacologic and nonpharmacologic
- RT burnout over misallocation of therapies
- Lack of consensus between members of the multidisciplinary team

WHERE DO WE BEGIN?

- Get buy in
- Assemble a team
- Identify areas for improvement
- Decide a location
- Design a pilot
- Obtain feedback
- Continuously improve
- Support the team

OUR INSTITUTIONAL EXPERIENCE

- Goals for Airway Clearance Pathway
  - Facilitate a more rapid return to premorbid baseline
  - Reduce length of ICU admission and total LOS by 10%
  - Standardize the approach to escalating or weaning therapy
  - Improved patient safety through fewer readmissions
- Indications for Airway Clearance Pathway
  - Patients 30 days and older
  - Admitted to 8 South, 8 Central, or PICU
  - Physiologies consistent with pneumonia, acute respiratory infection, and/or V/Q mismatch

WHO FITS THE PROTOCOL?

- Patients with acute respiratory illness
- Acute on chronic conditions needing increased therapies from baseline

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EXCLUSION CRITERIA

- Patients with Cystic Fibrosis, SMA, or congenital/progressive neuromuscular disease
- Patients with contraindications to a given therapy
- ***Team discussion should occur when patient is receiving PEEP > 12 cm H_2O, inhaled iNO therapy, or HFV***

WHAT DO WE MEASURE?

- Pulmonary history
- Characteristics of cough and secretions
- Sputum culture
- Breath sounds
- Respiratory rate
- Breathing pattern/work of breathing
- Prolonged expiration
- SpO2, PaO2, supplemental O2 requirement
- Chest radiograph

TEAM EVALUATION

- What therapies are indicated and why?
- How frequently should these be administered?
- If applicable, what settings should be used?
- When should the patient be scored next?
- Does the score agree with what the clinical team ordered?

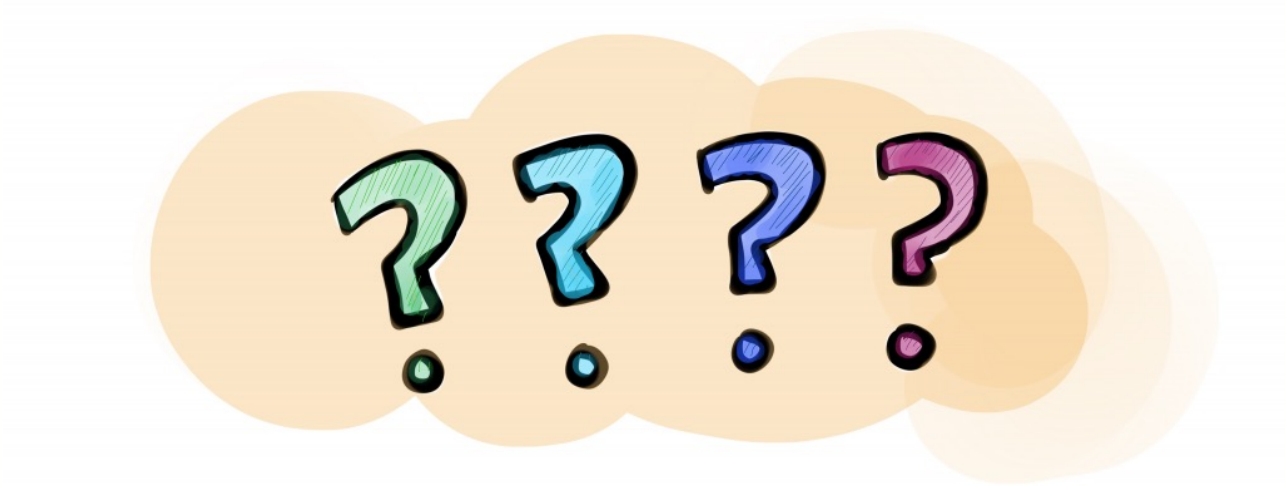
WHY DO IT?

- Quality Improvement
  - Improvement in patient outcomes measured by
    - Length of stay
    - Ventilator days
    - ICU admission
  - Reduction of costs to patients and the institution
    - Reviewing billable services
  - Allocation of resources
    - Optimize staffing and use of equipment
    - Calculating impact on FTEs
    - Processing, replacing, and servicing equipment

TAKE HOME POINTS

- Airway clearance therapies are part of the "bread and butter" of the respiratory care profession
- Little evidence exists to support the therapies we deliver day to day
- Research, research, research!
- Evidence-based medicine and the utilization of RT driven protocols can optimize the care we deliver at the bedside

THANK YOU



Further questions or comments can be directed to Nickelaj@chop.edu! Thank you for your time!