Respiratory Physiotherapy and MND

23rd January 2010
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Respiratory and MND

- Lung physiology
- The respiratory pump and MND
- NIV
- Respiratory Adjuncts
- Cough
- Airway Clearance
- Practical

Factors which affect airflow

- Airway Resistance
- Elastic Recoil Pressure
- Bronchial Stability
- Expiratory Pressure

Ventilation

- There is a difference of ventilation within the lungs due to the gradient of intrapleural pressure
- Alveoli expand passively, in the upright position alveoli are held more open in the apex than in the bases.
- Intrapleural pressure is more negative in non dependent regions due to the weight of the lungs
- Basal lung is relatively compressed in the resting state and expands better on inspiration than the apex

Ventilation

- Apex- intrapleural pressure is at its most negative » this pulls open the alveoli and increases their resting volume » leads to decreasing compliance.These alveoli have minimal ventilation as airflow favours maximal compliance
- Base- intrapleural pressure is at its least negative » tends not to pull open the alveoli » reduces their resting volume » leads to increased compliance. These alveoli have maximal compliance, will favour airflow so better ventilated

Ventilation and Inspiratory flow rates

- Slow inspiration under 200mls from FRC in the upright position, preferentially ventilates the dependent zones
- Maintaining the same volumes, but increasing the inspiratory flow rate will cause ventilation to be progressively directed to the upper zones

Ventilation and positioning

- FRC (resting volume) occurs at different volumes depending on the position
- In supine the FRC occurs at lower lung volumes due to increase abdominal pressure under the diaphragm, which decreases the outward recoil of the chest so ventilation is poor
- Closing volumes (CV) stay relatively stable in different positions so that when FRC is at a lower lung volume it is closer to CV and increases the likelihood of airway closure

Mobilising secretions

- PEFR - Peak expiratory flow rate
- PIFR – Peak inspiratory flow rate
- PEFR needs to be > 30-60 l/min to move mucus
- PEF/PIF needs to be >1.1 to achieve expiratory flow (J.Appl Physiology 1987;959-974)

The Respiratory pump and MND

- Respiratory muscle weakness
- Bulbar muscle dysfunction
- Inspiratory muscle weakness
- Expiratory muscle weakness
- Diaphragm weakness
- Increased work of breathing
- C02 retention
- Nocturnal hypoventilation – dyspnoea, orthopnoea, disturbed sleep, nocturnal desaturation, excessive sleepiness, morning headaches, drowsiness
- Aspiration, pneumonia and collapse / atelectasis
- Decreased Quality of Life
- Respiratory failure

Assessment and monitoring

- SNIP
- FVC
- ABG
- Overnight oximetry
- PCF
- Signs of Resp muscle weakness
- Increased work of breathing – increased resp rate
- Dyspnoea/ breathlessness
- Increased suction requirements
- Fatigue
- Bulbar dysfunction

NIV

- Nocturnal and daytime use, humidifier in the circuit
- Symptoms related to respiratory muscle weakness
- SNIP< 40cm/H_20
- FVC< 80%
- ABG
- Nocturnal desaturation on overnight oximetry ($Sa0_2$ < 90% for > 5% of the night)

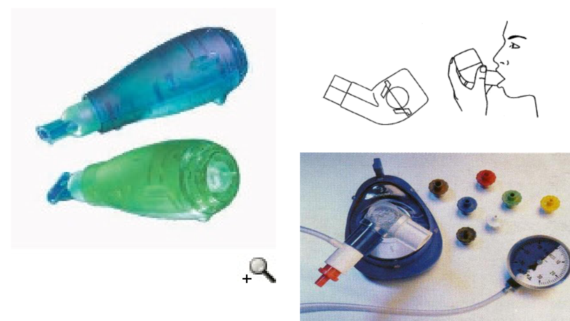
NIV

- Bourke et al, Lancet Neurology 2006,5(2):140-147
- In MND patients without severe bulbar dysfunction, NIV improves survival with maintenance of, and improvement in , QoL
- In patients with severe bulbar impairment NIV improves sleep related symptoms but is unlikely to improve survival

Respiratory adjuncts

- **Inspiratory muscle training** – further research is needed to determine whether it is beneficial.
- BTS/ACPRC guidelines, Thorax 2009

Respiratory adjuncts



HFCWO

- High Frequency Chest Wall Oscillation
- Positive pressure air pulses to the chest wall by an inflatable vest
- Expensive device
- Suggested benefits for secretion mobilisation and airway clearance.

HFCWO

- Pulses of air pressure applied to the chest wall by an inflatable vest produce shearing at the air mucus interface and repetitive peak expiratory flows during compression to help expel mucus like mini coughs
- Pulses compress the chest wall at frequencies from 5-30 Hz
- Chest wall compressed
- Only air in the airways oscillates

HFCWO

- Sine, Square and Triangular waveforms used in different machines
- Different settings – individual for each patient
- Need for long term studies
- Small sample size, single case studies

Cough

- Effective cough depends on the capacity of the respiratory muscles to increase intrathoracic pressures and dynamically compress the airways
- 3 phases – inspiratory, compressive and expiratory

Inspiratory phase of cough

- During inspiration the expiratory muscles are lengthened and strengthened. The inhalation of a large volume of gas will produce greater lengthening, optimise expiratory length-tension relationship and increase elastic recoil and this enables expiratory muscles to generate greater positive intrathoracic pressures.

Compressive phase of cough

- Glottis closure maintains lung volumes as intrathoracic pressures are building, minimises exp muscle shortening and creating an isometric contraction → maintains a more advantageous force-length relationship and generates greater positive intra-abdominal and intrathoracic pressures

Expiratory phase of cough

- Glottis is opened → high intrathoracic pressures developed during the compressive phase promotes high expiratory flow rates.

Expiratory flow

- Relationship between expiratory flow and airstream velocity depends on the cross sectional area of the airways(velocity=flow/cross sectional area), the velocity of the airstream increases as the cross sectional area decreases. As air flows from the periphery to the central airways the velocity of the gas increases. Creates a shearing force on the airway wall.

Cough Inefficiency

- Inhaling to high lung volumes will optimise expiratory pressures and will enhance expiratory airflow and velocity.
- With respiratory muscle weakness a limited volume of air is inhaled so expiratory pressures, air flow and velocity are reduced.
- Even mild to moderate expiratory muscle weakness will adversely afffect the expiratory pressures and expiratory flows which are needed for an effective cough. This increases the risk of atelectasis and pneumonia.
- If the first phase of coughing is limited then this limits the second and third phases of cough.

Aims

- To improve ventilation by increasing Tidal Volumes (TV)
- To maximise airway clearance by improving ventilation using the principles of collateral ventilation and interdependence
- To improve cough effort by increasing expiratory flows to clear secretions

Respiratory Pump

- In dynamic conditions inspiratory and expiratory pressures are generated by muscles of respiration.
- In static conditions, pressure is determined by elastic recoil, the elastic properties of lung parenchyma, airways, chest wall and gravity.
- Exhaling is passive and the chest wall is supporting and stopping expiration down into ERV and in MND there is minimal support from these muscles.

Breath Stacking

- At maximal inspiration, the lung tissue is fully expanded and the pulmonary recoil pressure is at its highest value.
- In MND because inspiratory muscles are weak and unable to achieve maximum inspiratory capacity (VC < 40-60%) then manual breath stacking can be effective and in combination with assisted cough can aid with expectoration of secretions.

Breath Stacking Technique

- Equipment:
  - Self inflating Ambu bag
  - One way valve and soft connector
  - Ambu face mask / PEP face mask
- Connect the face mask to the one way valve and use the soft connector to the Ambu bag.

Breath Stacking Technique

1. Patient should be in a relaxed position, either supine or semi reclined.
2. Instruct the patient to breathe in (if able) at the same time you inflate the ambu bag.
3. Place the face mask over the patients face ensuring a tight fit.
4. Compress the ambu bag, then let it refill and compress again
5. Repeat 2-3 times until maximum inspiration is reached

Breath Stacking Technique

6. Instruct the patient to hold the inspiration (if able) for 3 seconds.
7. Then follow with manual assisted cough to aid with secretion clearance.

Physiological Basis

- Improves pulmonary compliance by re-expanding atelectatic regions and clearing secretions
- Reduces airway resistance and work of breathing
- Uses the principles of collateral ventilation and interdependence.

Collateral Ventilation

- Due to positive intrabronchial pressure, air moves behind obstructed airways via collateral channels.
- Channels of Martin- interbronchial
- Canals of Lambert- bronchial-alveolar
- Pores of Kohn- interalveolar

Interdependence

- The mechanism by which air is moved into small airways obstructed by secretions by increasing tidal volume.
- Interdepence is where during inspiration, expanding alveoli exert a force on adjacent alveoli.
- This can assist in re-expansion of collapsed alveoli.

Coughing

- During a forced expiration from maximal inspiration, intrapleural pressures reach 200cmH20, partly due to the force of contraction of the muscles of expiration.
- Alveolar P = Pulm recoil P + intrapleural P
- This alveolar P is the driving force for expiratory gas flow and determines an effective cough.

Assisted cough in MND

- Decreased lung compliance → decreased pulm recoil pressure
- Weak respiratory muscles → decreased intrapleural pressure
- Leads to decreased alveolar pressure and reduced cough flows
- Alveolar P can be increased by increasing intrathoracic P through external chest wall or abdominal compression → increased cough flows.

Peak Cough Flows (PCF)

- Normal cough :

  -mean PCF = 360-1200L/min
- Recommended to start BS and AC when PCF < 270L/min and VC < 50% (Dean and Bach 1996)

Assisted Coughing

- Aim to ensure optimal lung volumes to achieve a high enough PCF to clear secretions
- Increase the expiratory flow rate by increasing intra-thoracic pressure through external abdominal and/or chest wall compression.

Assisted Coughing Techniques

- Abdominal Thrust
- Lateral Costal Compression
- Huff Technique
- Anterior Chest Wall Compression

Potential Adverse Effects

- Pneumothorax
- Gastric Distention and GER
- Abdominal Trauma
- Rib Fractures

Mechanical Insufflation/Exsufflation - Cough Assist

- Mechanically stimulates a cough through insufflation / exsufflation using positive (inspiration) and negative pressure (cough) causing a high expiratory flow to clear secretions
- Non invasive
- Inhalation phase
- Exhalation phase
- Pause phase
- 4-6 cycles

Cough Assist

- Applies positive pressure to the airway to expand the lung – deep breath
- Rapidly shifts to negative pressure creating a high expiratory flow
- Each change from positive to negative pressure replicates a cough cycle
- Manual or timed automatic cycles
- More effective when used with an assisted cough
- Combination of insufflation and exsufflation increases PCF in patients with severe respiratory muscle weakness (Chatwin et al 2003 and Winck and Miguel 2004)

Pressure Adjustment

- **Start with lower pressures 10-20Cm/H20 for inhale and exhale to acclimatise to the cycles**
- **Exhale pressures may go up to 40-45cm/H20**
- **Set:**
- **1.Exhale pressure first**
- **2.Block the end of the breathing tube**
- **3.Select Manual**
- **4.Slide the lever to the exhale position and hold it in place**
- **5.Observe the pressure gauge and adjust the pressure**
- **6.Turn the knob to the right to increase and to the left to decrease**.

Inhale Pressure

- Turn the Inhale flow knob to the right to provide a gradual deep inhalation.
- Block the tube
- Slide the manual control lever to the inhale position and hold it in place
- Turning the knob to the right sets the inhale pressure the same as exhale pressure
- Keep the tube blocked and switch Manual switch to the left and right to check pressures are correct.

Note

- If the patient does not receive a full deep breath turn the inhale flow button to the left.
- If this is not sufficient gradually increase the inhale pressure button.

Cough Assist Cycle

- Inhalation phase
- Exhalation phase
- Pause phase

- The dials on the left side of the machine control the timing.

Typical cough cycle Timings

- **Decreased inhale flow settings:**
- Inhale = 3-4 secs
- Exhale = 1-2 secs
- Pause = 1-2 secs
- **Increased inhale flow settings:**
- Inhale = 1.5-2.5 secs
- Exhale = 1-2 secs
- Pause = 1-2 secs

Note

- Aim to get a full insufflation and a rapid exsufflation
- Observe patient carefully
- To set automatic timing set switch to " Auto"
- Block the circuit and observe as the pressure gauge changes during the cycle.

Treatment

- **Familiarise patient with the device**
- **Try positive pressure first and only then move to both positive and negative pressure**
- **Trache (cuff needs to be inflated), facemask and mouth piece**
- **Instruct patient to actively inhale and exhale during the cycles as this allows the glottis to remain open resulting in unobstructive airflow**
- **4-5 cough cycles, followed by 20-30 secs rest to allow normal breathing pattern to return**
- **Remove and clear secretions**
- **Assisted cough during these cycles**

Treatment

- Full treatment consists of 4-6 sequences of cough cycles
- 1 treatment = 4-6 sequences
- 1 sequence = 4-5 cycles
- 1 cycle = 1 insufflation, 1 exsufflation and pause
- Intermittent operation only never use continuously

Treatment

- Position for most effective use of the diaphragm and for assisted cough techniques
- Finish with inhalation cycles
- Inhalation only can be used - positive pressure to increase vital capacity and chest wall mobility

Cough Assist

- **Contraindications**: bullous empysema, susceptibility to pneumothorax, pneumo-mediastinum, recent barotrauma, unstable CVS, recent oesophageal surgery, bronchial tumours, base of skull fractures, haemoptysis, lung surgery and chest drains, recent large abdominal surgery, known diagnosed lung pathology

Thank You

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