T E Oh: Intensive Care Manual

Organization Aspects

Chapter 4: Physiotherapy in the ICU

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Techniques of chest physiotherapy have been documented since 1901 for the treatment of a wide range of pulmonary disorders. Despite a large volume of research in the last 25 years, controversy persists on the optimal modalities to be employed. This is primarily due to inappropriate application of chest physiotherapy or variations in research design; for example, in the failure to

1. standardize nomenclature, patients studied and objective measures, and to

2. distinguish acute from chronic pathology and prophylactic from therapeutic treatment.

Physiotherapy nevertheless remains an important aspect of the overall management of an Intensive Care patient. A properly established Intensive Care Unit should provide for experienced physiotherapists on a 24 hour basis.

Rationale for Chest Physiotherapy

Following the institution of mechanical ventilation via an endotracheal tube or tracheostomy, pathophysiological changes occur in lung function that predispose the patient to pulmonary complications. Pulmonary insults and diseases magnify these pathophysiological changes. Some of these factors are outlined below:

1. Decreased mucocilliary clearance

The presence of an artificial airway increases mucus production and decreases ciliary activity. Inadequate humidification further impairs this mechanism.

2. Colonization of the lower respiratory tract with upper respiratory tract organisms

Contamination of the lower respiratory tract occurs during intubation and with intermittent cuff leaks. The number of organisms in the oropharynx is increased as hygiene is difficult in intubated patients. Infection is likely to occur in compromised patients, eg, debilitated patients, in the presence of hypoxia, acidosis, uraemia or prolonged hospitalization.

3. Ventilation-perfusion (V/Q) mismatch

Ventilation is preferentially distributed to nondependent lung regions in the paralyzed, mechanically ventilated patient. The mechanisms involved are thought to be loss of lung volume in the dependent lung resulting in a decrease in compliance, and the passive movement of the diaphragm. Normally diaphragmatic movement is greatest in the domed

portion (due to the stretch on its fibres). As this mechanical advantage is lost in the paralyzed, ventilated patient, the greatest diaphragmatic displacement is in the nondependent lung regions. Perfusion, however, remains greatest in dependent regions.

4. Increase in deadspace ventilation

If alveolar pressure is increased and/or pulmonary artery pressure is decreased, deadspace ventilation is increased. A decrease in alveolar perfusion occurs in nondependent lung regions due to a decrease in pulmonary artery pressure and the effect can be magnified with the application of positive end-expiratory (PEEP) especially in non-diseased lung units.

5. Uneven distribution of ventilation

Distribution of ventilation is altered by disease. Ventilation of a lung unit is determined by its local distensibility and airway resistance. A decrease in lung or chest wall compliance and an increase in airway resistance results in the closure of small airways at higher lung volumes and an increase in the closing volume. Failure of the airway to reopen leads to collapse of the lung unit and hypoxaemia. Ventilation is preferentially distributed away from those lung units that have a decrease in compliance and/or an increase in airway resistance. Other factors that promote alveolar collapse include the supine position, pain, use of sedatives/narcotics and immobility.

Techniques

Physiotherapeutic techniques are designed to minimize the effects of any disease state and promote normal function.

Physiotherapists are involved directly with the prevention of pulmonary complications. Changes in the status of other systems (cardiovascular, neurological, musculoskeletal, haematological, renal or nutritional) can influence techniques performed and expected outcomes.

The aim of physiotherapy are to:

1. Improve V/Q relationships, thereby decreasing the risk of alveolar collapse and pulmonary infection.

2. Maintain joint and soft tissue range.

3. Encourage active movements, thereby diminishing the risk of deep vein thrombosis, and promoting normal musculoskeletal and neurological function.

4. Encourage mobilization to minimize the detrimental effects of bed rest.

5. Initiate rehabilitation programmes focusing on major problems.

Positioning and Postural Drainage

Correct positioning should be an integral part of the management of the critically ill patient.

The influence of posture on the distribution of ventilation in awake, spontaneously breathing patients and sedated, mechanically ventilated patients has been studied, suggesting that the variation in pleural pressure gradient is not only dependent on posture, but also on selective contraction of inspiratory muscles. Therefore, in patients who are mechanically ventilated but not paralyzed, the distribution of ventilation can be altered by active contraction of the inspiratory muscles and depends on the difference in mechanical properties of the two hemithoraces.

Increasing lung volume from functional residual capacity (FRC) by either manual bagging or controlled breathing exercises, enhances V/Q matching by decreasing airway resistance, improving collateral flow and mobilizing secretions.

Unless a specific lung segment is to be drained, positions that increase FRC are indicated. Sitting with the hips flexed (not "slumped") and accurate side-lying allow the diaphragm greater mobility while the supine position should be avoided as it decreases FRC. Postural drainage positions should only be used for gravity-assisted drainage of specific lung segments. Certain conditions require special consideration when positioning the patient, especially prior to tipping (Table 1).

Table 1. *Conditions Requiring Special Consideration When Positioning*

1. Sever hypertension.
2. Acute myocardial infarction/cardiac arrhythmias.
3. Congestive cardiac failure/pulmonary oedema.
4. Raised intracranial pressure (eg, head injury, cerebrovascular accident, cerebral oedema).
5. Cerebral or aortic aneurysms.
6. Dyspnoea.
7. Oesophageal operations/hiatus hernia/regurgitation.
8. Eye surgery.
9. Peritoneal dialysis/haemodialysis/haemofiltration.
10. Ascites.
11. Abdominal distension.
12. Pneumonectomy.

Percussion and Vibration

Percussion and vibration are manual techniques that can be used in conjunction with posturing, postural drainage, manual bagging and controlled breathing exercises to assist the mobilization of secretions from peripheral to central airways. Certain condition that may require modification of the percussion technique (Table 2).

Table 2. *Conditions Requiring Modification of Percussion*

1. Fractured ribs, vertebrae or sternum.
2. Pleuritic or other chest wall pain, eg, carcinoma of the lung, secondary rib carcinoma, lung abscesses, pulmonary embolus.
3. Acute myocardial infarction and arrhythmias.
4. Haemoptysis.
5. Coagulopathies, thrombocytopenia, disseminated intravascular coagulation.
6. Osteoporosis.
7. Osteomyelitis of the rib cage.
8. Bronchospasm.
9. Incisions/burns/grafts.
10. Severe surgical emphysema.

Manual Bagging

Manual bagging can be used as an adjunct to other physiotherapy techniques to improve lung expansion. Various resuscitation or anaesthetic bags are available but only those bags capable of delivering 100% oxygen should be used. (See Chapter 6, Cardiopulmonary Resuscitation.) Bagging is used to:

1. Hyperoxygenate pre and post suctioning.
2. Improve V/Q matching by increasing lung volumes, increasing compliance and decreasing airway resistance.

Bagging is an effective, safe technique provided the operator continually adjusts the rate, tidal volume and pressure, in response to changes in the patient's lung compliance or airway resistance. The "bag-squeezing" technique using a four-to-five litre anaesthetic bag is generally not used due to complications of barotrauma and significant decreases in venous return. The potential complications of bagging include:-

1. Barotrauma due to high airway pressure.

2. Hypotension and decrease in cardiac output.

3. Raised intracranial pressure (ICP).

4. Hypoventilation due to poor technique or patient "fighting" the bagging.

5. Hyperventilation and loss of respiratory drive due to a fast rate.

The following guidelines promote a correct technique:

1. Select flow rate to achieve required fractional inspired oxygen (FIO_2).

2. Check operation of bag prior to connection to the patient.

3. Hyperventilate following connection.

4. Determine rate according to patient's respiratory effort. If the patient has no respiratory drive, bag at similar rate to ventilator rate unless otherwise indicated. If the patient does have a respiratory drive, synchronize manual breaths with patient's breaths

5. Consider bag volume, patient's size and airway pressure when determining volume.

6. Hyperventilate prior to suction and reconnection to ventilator.

Suctioning

Suctioning is required to stimulate the cough reflex and remove secretions in patients who are unable to cough or have an ineffective cough (despite other physiotherapeutic techniques, eg, forced expiratory techniques, huffing, tracheal rub and optimal positioning).

Suctioning is, however, a potentially dangerous technique. Complications of suctioning are:

1. Tracheobronchial trauma including mucosal haemorrhage, oedema, ulceration and destruction of ciliated epithelium.

2. Bronchial obstruction as damaged ciliated epithelium is repaired by squamous metaplasia and fibrous tissue.

3. Hypoxia. Definitive mechanisms are unknown but suggestions include suction-induced atelectasis or reflex bronchoconstriction caused by mechanical stimulation of the trachea.

4. Cardiac arrhythmias. Atrial and nodal arrhythmias are the most common and occur if the patient is breathing air while suctioned. Pre-oxygenation with 100% oxygen abolishes these arrhythmias. Vagal stimulation, however, can occur and may result in significant bradycardia or even cardiac and respiratory arrest.

In non-intubated patients who require suction via a nasotracheal or orotracheal route the risk of complications is high. Other precautions or contra-indications to suction in non-intubated patients are shown in Table 3. The following guidelines, therefore have been recommended:

1. Suction to be performed when indicated and not on a routine basis to decrease the risk of tracheobronchial trauma.

2. Hyperoxygenate to decrease the risk of hypoxia and cardiac arrhythmias.

3. Limit the suctioning time to fifteen seconds to decrease the risk of hypoxia.

4. Observe the patient's vital signs (including colour, distress, heart rate, respiratory rate, blood pressure and oxygen saturation) pre, during and post suction and discontinue treatment if any adverse effects occur.

Minitracheotomy should be considered for patients who require frequent orotracheal or nasotracheal suction and are at risk of developing respiratory failure due to sputum retention. (See Chapter 21, Endotracheal Intubation and Tracheostomy.)

Table 3. *Precautions/Contraindications to Suctioning*

1. Cerebrospinal fluid leaks.
2. Fractures involving the nose, face, base of skull.
3. Epistaxis, deviated septum, general facial trauma.
4. Coagulopathies.
5. Hyper-reflexic gag reflex.
6. Mouth and neck surgery.
7. Laryngospasm, glottic oedema.
8. Tracheitis, bronchospasm.

Patient Mobilization

Early mobilization is essential if the detrimental effects of bed rest are to be minimized. It may also decrease the rehabilitation time.

Positioning, passive and active movements and resistive exercises are routinely performed by physiotherapists. Mobilization also includes sitting the patient out of bed when vital signs are stable. Standing and ambulation with appropriate assistance and aids should be encouraged as this also decreases the need for frequent and vigorous chest physiotherapy. The tilt table may be used in the early rehabilitation of patients with:

1. General debilitation due to prolonged bed rest.

2. Cardiovascular instability.

3. Neurological dysfunction.

4. Musculoskeletal disorders.

Adjuncts to Chest Physiotherapy

1. Intermittent Positive Pressure Breathing (IPPB)

Despite early enthusiastic descriptions of the beneficial effects of IPPB in the treatment of acute asthma, chronic obstructive airways disease (COAD), pneumonia and prevention of post-operative pulmonary complications, the use of IPPB is now controversial. There is little clinical evidence to support its necessity, efficacy and cost-effectiveness over other forms of respiratory therapy. Complications are reported in the literature (Table 4).

Table 4. *Complications of Intermittent Positive Pressure Breathing*

1. Increased work of breathing.
2. Air trapping.
3. Risk of pneumothorax.
4. Carbon dioxide narcosis.
5. Depressed cardiac output.
6. Cross-infection.
7. Gastric distension.

2. Incentive Spirometry

Early studies found incentive spirometry to be more efficacious than IPPB or routine chest physiotherapy. Recent studies have failed to demonstrate that incentive spirometry offers significant advantages over other forms of respiratory therapy in the prevention of post-operative complications.

3. Periodic Continuous Positive Airway Pressure (CPAP) by Mask

The application of periodic CPAP by mask in the post-operative patient has been demonstrated to be more effective than IPPB, incentive spirometry, or deep breathing and coughing exercises alone. A more rapid increase in FRC occurs in patients who receive CPAP. The application of CPAP by mask for the treatment of respiratory failure secondary to low lung volumes is an area that requires further investigation. Potential complications of CPAP are:

1. Decrease in cardiac output; however, spontaneous ventilation decreases the incidence and severity of this complication.

2. Vomiting and aspiration of gastric contents; this is minimized if CPAP is used in awake, cooperative patients and by the insertion of a nasogastric tube to reduce gastric distension.

3. Carbon dioxide retention.

4. Skin erosion; minimized by the use of soft, easily molded silicone elastomer masks.

One single method of treatment, however, is unlikely to prevent post-operative complications. Any manoeuvre that encourages the patient to perform sustained maximal inspiration is likely to decrease the incidence of pulmonary complications. The costs involved in supplying these aids needs to be considered when discussing the effectiveness of these modalities.

Adverse Effects of Chest Physiotherapy

The problems of chest physiotherapy and their contributing factors and recommended treatment are shown in Table 5.

Frequency of Treatment

Ideally, physiotherapy is continued throughout a 24 hour period. The frequency of treatment is individualized for each patient and may vary from two hourly to four/six hourly. It is determined by assessment and response to treatment.

1. Assessment

(a) *Rationale for instituting mechanical ventilatory support.* The major indication for mechanical ventilation is acute respiratory failure. Other indications include:

(i) elective ventilation for high risk post-operative patients.

(ii) hyperventilation ($PaCO_2$ 25-30 mmHg (3.3-4.0 kPa)) to help control ICP and to prevent adverse sequelae of neurological and neurosurgical events.

(b) *Influence of other systems* including signs of sepsis, cardiovascular or neurologic dysfunction, metabolic and electrolyte disturbances, haematological disorders.

(c) *Respiratory function.* Evaluation of the following parameters is required:

(i) mode of ventilation and FIO_2;

(ii) respiratory mechanics (tidal volume or minute volume, respiratory rate, airway pressure);

(iii) arterial blood gases;

(iv) auscultatory signs;

(v) chest X-ray findings.

2. Response to Treatment

Selection of treatment techniques has been discussed in previous sections. All patient parameters require ongoing evaluation to promote safe and effective treatments. Routine treatment programmes are not only ineffectual but also potentially dangerous as important clinical signs may be missed.

Special Considerations

To effectively prevent secondary pulmonary complications it may be necessary to increase the frequency of treatment in the following circumstances:

1. Paralyzed Patient

Patients who are paralyzed and sedated and therefore in a controlled mode of ventilation, have an increased risk of developing progressive atelectasis due to physiological

changes described earlier. Major collapse and consolidation is also a significant possibility due to the loss of the cough reflex.

2. Positional Restriction

If correct positioning is not possible (eg, spinal fractures, elevated ICP, and skeletal traction) collapse/consolidation may occur in pulmonary segments which cannot effectively be treated.

3. Length of Treatment

Certain disease states (eg, severe hypoxaemia, cardiac arrhythmias, and elevated ICP) necessitate treatments to be kept brief and therefore an increase in frequency may be required.

4. Pre-existing Pulmonary Disorder (eg, COPD)

Immobility and artificial ventilation frequently aggravate the pathophysiological changes which occur with pulmonary disorders.

5. Poor Airway Control and Ineffective Cough

If the patient is unable to adequately maintain an airway or clear secretions effectively (eg, bulbar palsies, and postoperative patients) an increase in the frequency of treatment may prevent respiratory failure.

6. Abnormal Breathing Patterns

With spontaneous modes of ventilation (eg, Intermittent Mandatory Ventilation, Pressure Support, CPAP, and T-piece) paradoxical or shallow, rapid breathing patterns can occur thereby increasing the risk of collapse or consolidation.

7. Decreased Level of Consciousness

If the level of consciousness is decreased, whether it is due to artificial agents (eg, paralyzing agents, sedatives, or narcotics), neurological dysfunction or metabolic disturbances, pulmonary dysfunction can result.

If the patient is able to co-operate with physiotherapy, positioning and mobilization, then it may be possible to decrease the frequency of treatment. This would also contribute to the minimization of the detrimental effects of sleep deprivation.

Table 5. *Adverse Effects From Chest Physiotherapy*

Problem	*Contributing Factors*	*Remedial Action*
Decreased PaO_2	Low PaO_2	Treat with 100% O_2
	High FIO_2	Do not disconnect from ventilator.
	PEEP > 15 cmH_2O (1.5 kPa)	Use swivel connectors with a self-sealing diaphragm to minimize the decrease in PEEP during suction.
		Short treatment sessions.
Increased ICP	Non-paralysed patient	IV bolus of sedative, narcotic or paralysing agents.
	ICP > 15 mmHg (2.0 kPa)	
	Suction decreasing venous return	Capnometer incorporated into circuit to monitor.
	Increased $PaCO_2$ during manual bagging	P_{ET} CO_2.
		Short treatment sessions.
		Minimize other stimuli prior to treatment.
Hypertension & tachycardia	Pain, anxiety	IV bolus of sedative, narcotic.
Hypotension		
		Correct bagging technique.
	Hypovolaemia	Decrease rate to allow maximal expiratory time.
	Decreased CO	
	Air trapping in patient with severe COAD	

PaO_2 : Partial pressure of arterial oxygen.
$PaCO_2$: Partial pressure of arterial carbon dioxide.
P_{ET} CO_2 : Partial pressure of end tidal carbon dioxide.
CO : Cardiac output.