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The use of Mapleson-C circuit in airway clearance and lung expansion for patients with neuromuscular disease — a case report

Abstract

Background: Neuromuscular diseases involving respiratory muscles often requires tracheostomy for their airway management this entails ventilation and lung expansion techniques. Physiotherapy plays a vital role in managing these patients for weaning from ventilators, improving lung expansion and airway clearance. In our Indian Critical Care Unit setup there is a lack of evidence supporting the use of Mapleson-C circuit in neuromuscular diseased patients with tracheostomy. The study was to determine the efficacy of Mapleson-C circuit in airway clearance and lung expansion in neuromuscular disease patient.


Case presentation: A 63-year-old male patient with the diagnosis of Guillian Barrie syndrome (GBS) required mechanical ventilation support with tracheostomy and had undergone intercostal drainage for pyothorax on the left side. After weaning from mechanical ventilator support the patient required Airway Clearance and Lung expansion Techniques. Mapleson-C circuit applied was for 3 days totaling 18 sessions (for day time 4 sessions, 15 minutes/session, 12 breaths/minute, during night time only 2 sessions). Chest radiograph (Atelectasis Score) and amount of sputum cleared were used as primary outcome measures.

Conclusion: Chest radiograph score showed significant improvement from score 4 to 1, and more amount of sputum removed. In the secondary outcome measures, Improvement in saturation of oxygen (86% to 98%), arterial blood gas analysis (PaO₂ increased from 70 mm Hg to 94 mm Hg and PaCO₂ decreased from 50 mm Hg to 42 mm Hg), reduced use of accessory muscle of respiration and decrease in respiratory rate of about 10 breaths/minute. Finally, the Mapleson-C circuit is a very effective technique for lung expansion and airway clearance.

Key words: Guillian Barrie syndrome, Mapleson-C circuit, airway clearance technique

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Introduction

Guillain Barre syndrome (GBS) is an autoimmune neuroinflammatory disorder of the peripheral nerves clinically characterized by acute and symmetric flaccid paraparesis with areflexia [1]. Acute GBS is an acute inflammatory demyelinating disease of the peripheral nerves [2]. Which affects the normal transmission of electrical impulses along these nerves and consequently the function of the organs and the tissues which they innervate [3, 4].

Symptoms can develop over 10–14 days, with the nadir usually being reached by the third and fourth week. However, the progress of this disease is variable and total paralysis and respiratory arrest can occur within 48 hours [5]. The incidence of typical Guillain Barre syndrome has been reported to be relatively uniform between 0.6 and four cases per 100,000 per year throughout the world [6].

Neuromuscular diseases involving respiratory muscles often requires a tracheostomy for their airway management this entails ventilation and lung expansion techniques. Physiotherapy plays a vital role in managing these patients for weaning from ventilators, improving lung expansion and airway clearance.

Manual hyperinflation is a technique which provides a greater than baseline tidal volume to the lungs using a bag or manual re-breathing circuit [7, 8]. It is used by physiotherapists in the respiratory management of intubated patients [9, 10]. Evidence supports the use of manual hyperinflation for re-expanding acute atelectasis [11], improving respiratory compliance [12–15], reducing inspiratory resistance [12], increasing oxygenation [16, 17] and enhancing the removal of secretions [13].

In our Indian Critical Care Unit setup there is a lack of evidence supporting the use of Mapleson-C circuit in neuromuscular disease patients with a tracheostomy. The study was to determine the efficacy of Mapleson-C circuit in airway clearance and lung expansion in neuromuscular disease patients.

Case presentation

A 63-year-old man was admitted to our hospital with the chief complaint of progressive, bilateral, symmetric, and ascending motor weakness in a lower limb. He felt aggravating motor weakness in both lower extremities, and he could not walk independently owing to incomplete flaccid paralysis. Subsequently, he developed bilateral upper extremity

weakness, dysphagia, and slurred speech without definite higher cortical dysfunction. Magnetic resonance imaging (MRI) study of the brain was non-specific.

Electrodiagnostic study revealed generalized, acute polyneuropathy of motor axonal type on presentation. A cerebrospinal fluid study from lumbar puncture showed a red blood cell count of 0/mm³, a white blood cell count of 3/mm³, a glucose level of 82 ng/dL, and a protein level of 102 ng/dL.

He had no history of diabetes mellitus, hypertension or operation. He was diagnosed as GBS (Table 1) and treated with intravenous immunoglobulin. At that time, he required maximal assistance to stand, and a wheelchair to ambulate. The muscle strength was grade 3/5 in both upper extremities and grade 2/5 in both lower extremities on the Medical Research Council scale. He had complained of dyspnoea and required mechanical ventilation support with tracheostomy and undergone intercostal drainage for pyothorax on left side. After weaning from mechanical ventilator support the patient required airway clearance and lung expansion techniques. He was admitted into the Intensive Care Unit for future medical management.

The patient was positioned lying on his side (bed flat) so that the more affected lung, as seen on the chest x-ray, was uppermost for intervention. Suction of the airways and the tracheostomy tube to clear secretions occurred immediately and again in 5 minutes followed by 5 minutes of lying on his side alone to allow the patient to settle without interruption. At the end of the ten minutes, 12 breath/minute manual hyperinflation breaths were delivered to the patient using the Mapleson-C circuit at FiO₂ < 0.6

Table 1. Major diagnosis criteria for GBS. According to: [5]

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|-----------|---|
| Motor | Progressive weakness of the skeletal muscles, generally ascending and symmetrical reduction or loss of deep tendon reflexes Reduced pulmonary capacity Weakness of facial muscles and dysphagia |
| Sensory | Parasthesia in extremities Reduced proprioception Sensory loss occurs in stocking — glove distribution |
| Autonomic | Hypertension, hypotension or labile blood pressure Tachycardia or bradycardia Cardiac arrhythmias |

by the mechanical ventilator (calibrated with an oxygen analyzer). A blender was used in the circuit to provide the FiO_2 .

Mapleson-C circuit applied for 3 days totaling 18 sessions (for day time 4 sessions, 15 minutes/session, 12 breaths/minute, during night time only 2 sessions).

A manometer was included in the circuit and the patient was manually hyper-inflated to a maximum peak airway pressure of 40 cm H_2O with a breath hold of no less than two seconds maintained at the end of the inspiratory phase. Expiration was passive and unobstructed to facilitate expiratory flow with no positive end expiratory pressure applied. Suction was performed at the end of manual hyperinflation. A closed-suction system was used for the patient and three suction passes were completed in total.

Chest radiograph (radiographic grades) and amount of sputum cleared were used as primary outcome measures. Chest radiograph grades showed significant improvement from score 4 to 1, and more amount of sputum removed. In the secondary outcome measures, improvement in saturation of oxygen (86% to 98%), arterial blood gas analysis (PaO_2 increased from 70 mm Hg to 94 mm Hg and PaCO_2 decreased from 50 mm Hg to 42 mm Hg), reduced use of accessory muscle of respiration and decrease in respiratory rate from 32 to 22 breaths/minute.

Discussion

The Mapleson-C circuit cleared significant amount of secretions. The increase in sputum clearance with the Mapleson-C may be explained by previous laboratory studies which showed that the Mapleson-C delivered higher peak expiratory flow rate, peak inspiratory pressure, and tidal volume [18, 19].

The transport of sputum in the bronchial tree has been described since the 1970s and may, in part, be attributed to two-phase gas-liquid flow [9, 20] which suggests that the greater the difference in flow between expiration and inspiration, the better the secretion clearance.

In our patient arterial blood gases analysis were taken regularly to assess the effectiveness of respiration and detect the development of hypoxia, respiratory acidosis and impending respiratory failure before clinical signs of respiratory insufficiency became evident. A reduced arterial oxygen level below 60mm Hg and a carbon dioxide level above 50 mmHg indicate severe hypoxia and respiratory acidosis and impeding respiratory failure.

In GBS hypotonia of the respiratory muscle also occurs as a result of muscle weakness and fatigue. This results in smaller resting lung volumes and a lower respiratory force being generated. The use of the accessory muscles is needed in order to maintain adequate ventilation. However, this results in increasing oxygen demand which in turn exacerbates the problem of respiratory insufficiency and alveolar hypoventilation [21].

Mapleson-C circuit is a simple, but effective, measure, which was used to help to reduce the incidence of hypoxia and respiratory acidosis. The oxygen was administered through a re-breath mask. This increases the concentration of oxygen in the lungs and helps to set up a concentration gradient between the alveoli and the blood allowing more oxygen to diffuse into the blood and be transported to the tissues.

Conclusion

This discussion focused on the pathophysiology of the condition and the effect that the demyelination of the peripheral nerves has on the respiratory muscles paralysis and explains the Mapleson-C circuit is a very effective technique for lung expansion and airway clearance.

Consent

Written informed consent was obtained from the patient for publication of this case report.

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Commentary

Manual hyper inflation is commonly used in intensive care and high dependency units throughout the UK as part of physiotherapy treatment as indicated for patients with retained secretions and reduced basal expansion and/or atelectasis regardless of diagnosis. We are not familiar with the Mapleson-C circuit specifically but we have experience in using an equivalent circuit for the above intervention.

Sarah Beamer, Anne English

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