

Management of chronic basal lung collapse in a mechanically ventilated tetraplegic individual using Biphasic Cuirass Ventilation (BCV) – a case report

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CASE PRESENTATION

We present the case of a 22-year-old male third-year medical student, who sustained a C2 AIS A spinal cord injury (SCI) following a shallow-water dive. Emergency surgical decompression and anterior fixation was performed on the same day. He was then repatriated to the UK, where he was admitted to his local Major Trauma Centre (MTC) and underwent further, posterior cervical fixation before a transfer to the National Spinal Injuries Centre (NSIC) a total of 81 days post-injury for further respiratory management and rehabilitation.



Chest imaging on admission revealed a right middle and lower lobe collapse (Figure 1). During the first eight months post-injury, he experienced four episodes of lower respiratory tract infections (LRTIs), despite an extensive multidisciplinary treatment programme. This included high tidal volume and pressure-controlled ventilation via a cuffed tracheostomy tube, combined with intermittent positive pressure breathing and mechanical insufflation-exsufflation techniques to enhance secretion clearance. Frequent manual hyperinflation, and optimal positioning strategies were employed alongside specific targeted manual techniques and oral carbocisteine, nebulised hypertonic (3 and 6%) saline and N-acetylcysteine mucolytic agents. In addition, he underwent several bronchoscopies with lavage and instillation of Dornase Alfa to aid mucus clearance and basal recruitment, clearing moderate amounts of thick yellow sputum deep within the right base (see fig. 2). Despite all of this, serial chest X-rays and CT images consistently demonstrated persistent collapse of the right middle and lower lobes.



In a relatively novel move, negative pressure ventilation using the Biphasic Cuirass Ventilation (BCV) system was introduced (fig. 4), to further enhance the more conventional techniques describe above. The continued aim was to achieve re-expansion, but functionally to reduce the incidences of chest infection as well as set up the individual for long term chest health to facilitate a long, healthy life.



Since commencing a programme of BCV intervention as an inpatient, the subject experienced no LRTI in 6 months. A subsequent infection at month 7 required a course of IV antibiotic treatment but crucially needed no change in daily physical intervention or routine. This has implications for management of future chest infections at home and avoiding unnecessary hospital admission. We also found an increase in daily secretion yield shortly after the start of BCV usage, with a gradual reduction in the following months. This yield however is more than prior to BCV usage which may be attributed to a more effective ventilation and secretion clearance regime. The appearance on the chest radiograph substantially improved on discharge but did not completely resolve (fig. 3).



The subject was discharged home with the BCV as described in figure X. At the post discharge follow –up appointment, no further incidences of chest infection were reported, as was a further reduction in pulmonary secretion yield. A Chest X-ray showed complete resolution of the right basal collapse (fig. 5).

WHAT IS BCV?

With origins in mechanism of action based on the Iron Lung, BCV was developed in the early 1980's¹ with first human trials performed in 1994². BCV delivers both external negative and positive pressure via a cuirass shell to control both phases of the respiratory cycle¹. Limited evidence specifically for SCI is available but it has been shown to resolve areas of post operative lung collapse^{3,4} in individuals with non-neuromuscular disorders and can enhance secretion clearance⁵.



Figure 6. The Hayek RTX BCV device and cuirass BCV shell

BCV UTILISATION

The total diaphragm paralysis experienced in the subject and therefore lack of any active basal excursion contributed to difficulty achieving basal lung expansion. We utilised a continuous negative pressure mode to passively draw the diaphragm inferiorly and also used a control mode to 'actively' trigger both intermittent positive pressure and a mechanical insufflation: exsufflation device

To our knowledge, this is the first documented case of using BCV as a treatment component to directly affect and reduce an area of chronic atelectasis in a fully ventilated SCI individual. This demonstrates the importance of an MDT approach in a specialist clinical setting



Figure 2. Bronchoscopy

RATE/INCIDENCE OF CHEST INFECTIONS

Pre BCV – 50% (4 in 8 months)
With BCV – 11% (1 in 9 months)
Post Discharge with continued usage of BCV – 0 (0 in 4 months)

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Fig. 1. NSIC Admission



Fig. 3. NSIC Discharge



Fig. 5. 4/12 post discharge