Innovative chest physiotherapy techniques (the MetaNeb® System) in the intubated child with extensive burns

Alexandra Ferguson*, Sarah Wright

Children's Health Queensland Hospital and Health Service, Brisbane, Australia

**Abstract**

Introduction: The Metaneb® is a new generation Intrapulmonary Percussive Ventilation device utilised by the physiotherapist to assist airway clearance by providing calibrated oscillations during inspiration up to 3.8Hz. Predominantly used in the adult chronic respiratory patient, with anecdotal evidence in intubated patients, it was also proven to be safe in a paediatric lung model lab study. This case report outlines the first use of the Metaneb® with an intubated child in Australia. The 8 year old patient was retrieved to Lady Cilento Children's Hospital with 61% total body surface area flame burns. The child was difficult to ventilate, immobile, and had retained secretions. The chest x-ray (CXR) demonstrated multifocal regions of atelectasis.

Study objectives: To report safe and effective use of the Metaneb® airway clearance in the paediatric intubated patient.

Methods: The Metaneb® was applied using an open ended bagging circuit on Continuous High Frequency Oscillation mode for a period of 10 min per treatment. The circuit contained an inline nebuliser containing 5ml 0.9% normal saline. PEEP was maintained and variable volume breaths were delivered with suction performed as required. Outcome variables to be measured included sputum weight and quality, CXR, and Peak Inspiratory Pressure (PIP) values pre and post treatment. Vital signs were monitored throughout.

Results: The patient's vital signs remained stable throughout intervention. After 4 days of treatment twice daily, there was resolution of focal changes on CXR, improvement in secretions, a reduction in PIP and the patient was extubated.

Conclusion: The Metaneb® was used safely and effectively in this patient to assist in resolution of respiratory pathology. Metaneb® provided a new option for physiotherapy treatment when positioning and handling restrictions limited usual care. This ultimately optimised PICU Length of stay and patient morbidity and mortality. Metaneb® provided by Hill-Rom Australia.

1. Introduction

The MetaNeb® System is a therapeutic device utilized by the physiotherapist to assist with airway clearance and lung expansion by providing a simultaneous combination of positive pressure, continuous high frequency oscillations and aerosol delivery. This type of therapy has been used in adult chronic respiratory patients ref. [5] and there is previous evidence in the management of atelectasis in children ref. [2]. In the critical care setting there are case reports ref. [4] and in ventilated paediatric patients a retrospective review ref. [3] and benchtop study ref. [1]. This case report outlines the first use of The MetaNeb® System with an intubated child in Australia.

2. Case summary

An 8-year-old boy, previously well, presented to a small regional hospital in Queensland, Australia following a significant flame burn injury. He was subsequently retrieved to a larger regional hospital where he was intubated and ventilated for debridement of the burns. The Total Body Surface Area affected by burns was classified as 61%. Day 3 post injury the child was retrieved to the tertiary Paediatric Intensive Care Unit (PICU) at Lady Cilento Children's Hospital...
Hospital (LCCH) in Brisbane.

On day 4 post injury donor sites were harvested and burns debrided. The child experienced significant blood loss and no grafting was completed. On day 6 and 8 post burn the patient had a Split Skin Graft (SSG) of his posterior torso, buttocks, posterior upper thighs, right lower leg and bilateral upper arms (see Fig. 1). The initial post-operative orders required that the patient remain ventilated and deeply sedated in prone position, minimal movement and repositioning was allowed so that shear forces over graft sites were completely avoided. On day 6 post injury the patient became septic, this was associated with a systemic inflammatory response and respiratory deterioration. The patient became difficult to ventilate and the chest x-ray (CXR) demonstrated multifocal regions of atelectasis change (see CXR 1). The patient's level of sedation resulted in no spontaneous cough. Indicators for respiratory physiotherapy treatment included increasing ventilator requirements, raised peak inspiratory pressures (PIP's), and retained secretions. The patient was systemically unwell with associated hemodynamic instability with episodes of hypotension requiring fluid resuscitation and inotropes.

Conventional physiotherapy techniques were extremely limited due to the new grafting sites. Physiotherapy treatment included repositioning using bed tilt only, manual hyperinflation (MHI), saline lavage, suction and passive mobility of the unaffected joints. These techniques had limited effectiveness and secretions remained difficult to access with palpable secretions persisting post intervention.

MetaNeb® treatment was implemented, following consultation with LCCH PICU Medical Consultants and USA centres with experience using the device in a ventilated patient. As the ventilator being used for this patient had not been tested with the MetaNeb®, it could not be used through the ventilator circuit. The MetaNeb® was attached to an approved 50psi oxygen source and applied using an open-ended bagging circuit (FiO₂ 1.0) in Continuous High Frequency Oscillation mode (230 breaths per minute, 3.8Hz) for a period of approximately 10 minutes per treatment. The occlusion ring was placed in the circuit to ensure the exhalation port is blocked to prevent loss of volume. The circuit contained an inline nebuliser containing 5ml 0.9% normal saline. Pressure was maintained between 10 and 20cmH₂O, monitored on the MetaNeb® manometer and variable volume breaths were delivered. Following a series of breaths on the MetaNeb®, secretion mobilization was evaluated via palpation; subsequently the patient was disconnected from the MetaNeb® and reconnected to the bagging circuit. Manual Hyperinflation with expiratory flow bias technique was utilized to mobilize secretions to the main airways and suction via ETT performed as required. This cycle of treatment was repeated until secretions were no longer palpable and ETT mucus clearance.

CXR 1. Pre-MetaNeb® bilateral midzone opacification and right upper lobe and left lower lobe changes.
Minimal disconnection time from the ventilator which is vital in PEEP dependent patients.
Pressure monitoring throughout treatment on MetaNeb® — attenuation of oscillation relates to ETT size, safe within paediatric lung model with a range of ETT sizes.
User friendly - mobile, no battery, easily connected to ventilated and non-ventilated patients, short treatment time.
Useful for patients where manual techniques contraindicated e.g. burns, low platelets.

Observed limitations of The MetaNeb® in this patient case:

- Less tactile feedback through MHI circuit in oscillatory mode.
- Oscillation increased the resistance in MHI circuit, with suboptimal ability to increase expiratory flows; this was resolved by disconnecting the MetaNeb® and finishing treatment with MHI to facilitate expiratory flow bias.
- If patient unstable and PEEP dependent it would beneficial to use In-Line MetaNeb®, this may require validation from the ventilator manufacturers to use MetaNeb® in-line.

This is a single case report and thus may have limitations in a more generalised context; however, it demonstrates safe, effective and successful use of the MetaNeb® in a paediatric ventilated patient.

The MetaNeb® System is an innovative device which was highly successful in the treatment of this critically unwell child. This case study suggests that this device may be beneficial in atelectasis secondary to poor secretion clearance in ventilated paediatric patients, and future studies are recommended to further evaluate the clinical efficacy in this population.

Conflict of interest

Hill-Rom Company, Inc. provided funding to cover the publishing fee for this journal.

References

[1] K. Bullock, C. Smallwood, Pressure attenuation across an ETT during CHFO with the metaneb system in a pediatric lung model, Crit. Care Med. 42 (12) (2014) 669 (Suppl.).
[2] K. Deakins, R.L. Chatburn, A comparison of intrapulmonary percussive ventilation and conventional chest physiotherapy for the treatment of atelectasis in the pediatric patient, Respir. Care 47 (10) (2002) 1162–1167.
[3] S. Morgan, C.P. Hornik, N. Patel, W.L. Williford, D.A. Turner, I.M. Cheifetz, Continuous high-frequency oscillation therapy in invasively ventilated pediatric subjects in the critical care setting, Respir. Care 61 (11) (2016 Nov) 1451–1455.
[4] S. Ortiz-Pujols, L.P. Boschini, C. Klatt-Cromwell, K.A. Short, J. Hwang, B.A. Cairns, S.W. Jones, Chest high frequency oscillatory treatment for severe atelectasis in a patient with toxic epidermal necrolysis (TEN), J. Burn Care Res. 34 (2) (2013) e112–e115.
[5] M. Paneroni, E. Clini, C. Simonelli, L. Bianchi, F. Degi Antoni, M. Vitacca, Safety and efficacy of short-term intrapulmonary percussive ventilation in patients with bronchiectasis, Respir. Care 56 (7) (2011) 984–988.