Biphastic Cuirass Ventilation (BCV)

Selection of Recent Studies
#102 - INVESTIGATION OF THE EFFICACY OF AN EXTERNAL VENTILATOR (RTX®) FOR CHILDREN HOSPITALIZED WITH RESPIRATORY DISORDERS

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Introduction: The RTX® respirator (United Hayek Medical, London, United Kingdom) is an external ventilator that uses a cuirass. The cuirass is a plastic shell over the thorax, by which physiological ventilatory assistance is obtained quickly by simply making internal pressure adjustments within the cuirass. The RTX® does not cause baro-trauma, volutrauma, or the possible development of pneumothorax, as seen with positive pressure ventilation (PPV). Furthermore, the clearance mode also helps to clear sputum. Because the pathophysiological characteristics (peripheral airway resistance due to small airway size, hyperplasia of bronchial goblet cells, etc.) of children often make sputum clearance difficult during respiratory disorders, use of the RTX® is thought to be effective in children who can rapidly progress to respiratory failure. We have seen that many children in a poor mood because of a respiratory disorder slept well after starting the RTX®, and their respiratory status stabilized. Therefore, we investigated the efficacy of RTX® treatment in children. Methods: An RTX® was used first in continuous negative mode for 1 to 2 hours, followed by secretion clearance mode to clear sputum. The above procedure was performed twice daily. The Modified Pulmonary Index Score (MPIS), which consists of the six categories [heart rate (HR), respiratory rate (RR), accessory muscle use, inhalation-exhalation ratio, wheezing, and SpO2] was observed on the day of starting the RTX® and the next day. The degree of improvement in each category was investigated for different levels of severity. A questionnaire was also given to the medical staff who applied the RTX® to investigate its efficacy. Results: There were 59 patients in the moderate group with MPIS ≤ 11 and 13 patients in the severe group with MPIS ≥ 12. Significant improvements in MPIS were obtained in both the moderate and severe groups. By individual MPIS category, the level of improvement was the greatest in HR (actual data significantly decreased from 144 ± 20/min to 123 ± 19/min), followed by SpO2, wheezing, and RR. In comparison with the level of improvement in each category by level of severity, the level of improvement in accessory muscle use was found to be significantly better in the severe group. In the survey of medical staff, 13 (88%) replied that the RTX® was effective. Two major reasons were the smoothness of sputum clearance and improved sleep after wearing the RTX® compared to before use. Conclusion: The RTX® for children with respiratory disorders is an effective method by which significant improvement in MPIS is obtained regardless of the level of severity. The mechanisms for this improvement are thought to be involved in stabilizing circulatory dynamics, facilitating secretion clearance, and decreasing effort with respiration due to support of respiratory muscle use. The RTX® is a unique ventilator which aims at improving a child's breathing problem using different mechanisms from PPV.

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Effects of extrathoracic mechanical ventilation on pulmonary hypertension secondary to lung disease

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Abstract
Purpose Biphasic cuirass ventilation (BCV) is a form of non-invasive extrathoracic positive and negative pressure mechanical ventilation. The present study was conducted to quantify our positive experience using BCV to dramatically improve gas exchange and cardiac function in patients with acute exacerbation of chronic respiratory failure and secondary pulmonary hypertension (PH).
Methods BCV was applied for 2 weeks in 17 patients with PH caused by lung disease. Ventilation sessions were limited to 1 h per day to prevent exhaustion. To assess respiratory and circulatory effects, percutaneous arterial oxygen saturation (SpO2) was measured before and after each daily BCV session, and right heart catheter test [mean pulmonary artery pressure (mPAP), right atrium pressure (RAP), pulmonary artery occlusion pressure (PAOP) and cardiac index (CI)] and serum N-terminal pro-brain natriuretic peptide (NT-proBNP) were measured before and after a series of BCV sessions.
Results SpO2 transiently improved after each BCV session. After a series of BCV, mPAP decreased from 27.2 to 22.4 mmHg (p = 0.0007), PAOP, CI and serum NT-proBNP levels decreased compared with baseline. No patients were treated with epoprostenol, iloprost, bosentan or sildenafil for PH.
Conclusion BCV may improve circulatory function in patients with PH caused by lung disease.

Keywords Biphasic cuirass ventilation · Pulmonary...
BIPHASIC CUIRASS VENTILATION USE IN BRONCHIOLITIS; A PROSPECTIVE STUDY
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**Learning Objectives:** Acute respiratory failure from viral bronchiolitis for children 0–2 yr of age is one of the leading causes of pediatric intensive care admissions. Non invasive ventilation with positive pressure has shown promise in decreasing the need for intubations. Continuous negative extra-thoracic pressure ventilation by way of Biphasic Chest Cuirass, BCV, is an alternative noninvasive modality of ventilation for use in bronchiolitis. The purpose of this study was to see if BCV is a means of noninvasive ventilation that is easy and safe to use in infants with respiratory failure from bronchiolitis. There are no prospective clinical studies in pediatrics using this promising modality of ventilation. **Methods:** A prospective single center pilot study of infants admitted with respiratory failure from bronchiolitis to the PICU from 2012–2013. Study participation involved placement on BCV and monitoring the patient using a severity score. Safety was determined by development of adverse outcomes including skin breakdown, agitation, delay in enteral nutrition, and pneumothorax. Additional secondary outcomes were length of stay need for escalation of respiratory support and length of time on supplemental oxygen. **Results:** Of the 15 patients enrolled (67% male), the median severity score was 3.7 at initiation of BCV. There were no reported adverse outcomes. Average length of stay in the PICU was 2.9 days. Number of days until full feeds was 1.6. Number of day on supplemental oxygen was 3.1. Two patients required higher level of respiratory support. **Conclusions:** Continuous negative pressure ventilation by Biphasic Chest Cuirass is a safe and easy to use as a means of respiratory support in bronchiolitis among children 1 to 24 mo of age.
Assessment of BCV for prevention of hypoventilation during interventional bronchoscopy using a rigid bronchoscope

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Background:
Interventional bronchoscopy using a rigid bronchoscope requires deep general anesthesia to prevent bucking and body movement during treatment, and the weak point about this technique is the possibility that excessively deep anesthesia can inhibit patient respiration and result in hypoxia. There is no effective way to overcome this problem.

Objectives:
The purpose of this study was to investigate whether the use of Biphasic Cuirass Ventilation (BCV) using a rigid bronchoscope can prevent hypoventilation during interventional bronchoscopy.

Methods:
Between August 2010 and October 2013, 14 patients received interventional bronchoscopy by a rigid bronchoscope with combined use of BCV. The underlying diseases/disorders in these 14 patients included tracheal stenosis secondary to lung cancer in 11 patients, post-intubation tracheal stenosis in 1, rt. bronchial stenosis due to esophageal cancer in 1, and post-tuberculosis bronchial stenosis in 1. BCV was used in all patients, and Tidal volume, SaO2, PaCO2, and frequency of discontinuation of procedure were monitored.

Results:
The treatment procedure could be safely performed in all the patients. It was possible to fully maintain minute ventilation during treatment and none of the patients experienced discontinuation of procedure due to hypoxia. Therefore, patients were able to receive sufficient anesthesia, which could lead to reduced bucking during treatment. There were no complications associated with BCV.

Conclusion:
During interventional bronchoscopy using a rigid bronchoscope, the use of BCV enabled the maintenance of ventilation during treatment and administration of sufficient anesthesia, suggesting potential clinical usefulness. We strongly recommend this technique to be tested further, especially in medical facilities that have hesitated to use a rigid bronchoscope or those anxious about respiratory management during treatment using a rigid bronchoscope.
Use of Biphasic Cuirass Ventilation During Bronchoscopy in a Critically Ill Infant

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Abstract

SESSION TITLE: Bronchology/Interventional Student/Resident Case Report Posters I

SESSION TYPE: Medical Student/Resident Case Report

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INTRODUCTION: Spinal muscular atrophy type 1 (SMA-1) presents in infancy with progressive weakness of the lower motor neurons, often leading to early death secondary to respiratory complications. Because of an impaired cough reflex and poor airway clearance, pediatric patients with SMA-1 are at risk for severe lower-respiratory tract complications during respiratory infections. The introduction of noninvasive ventilation (NIV) has been shown to reduce hospitalizations and intensive care admissions thus improving the prognoses of these children. (1)

CASE PRESENTATION: We report on a 2-month-old patient with SMA-1 who was transferred to our facility with a 1-week history of upper respiratory symptoms of cough and congestion. Upon arrival she continued to have tachypnea in spite of respiratory support with high-flow nasal cannula. Chest radiography showed right middle and lower lobe atelectasis with a “bell shaped” chest and nasal swab for viral PCR was positive for Coronavirus. Because of continued respiratory distress, complicated by underlying hypotonia, we decided not to intubate. Instead, BCV delivered by the Hayek® RTX ventilator was initiated. Although aggressive interventions were employed, the patient had no significant improvement and required flexible bronchoscopy while on BCV. Despite her small size and the presence of the bronchoscope in her airways, the patient tolerated the procedure with no desaturations. Unlike similar procedures done by passing a scope through an endotracheal tube, complications such as hypoxia and occlusion of the airway did not occur. In the subsequent week, four more bronchoscopic procedures were necessary utilizing similar techniques to successfully re-inflate the right lung while still on BCV.

DISCUSSION: Bronchoscopy and bronchoaveolar lavage in patients with respiratory distress is often complicated by hypoxemia (2). To our knowledge, this is the first report of successful flexible bronchoscopy and lavage in an infant utilizing BCV instead of positive pressure ventilation. Although our case report focuses on an infant, we were able to successfully perform the same procedure utilizing BCV with similar outcomes in an adolescent with chronic respiratory failure and atelectasis.

CONCLUSIONS: There have been no other publications on the use of BCV during flexible bronchoscopy. Further studies are needed to confirm the safety and efficacy of BCV-supported bronchoscopy in infants and children.

Reference #1: Keating, JM, Collins, N, Bush, A, Chatwin, M. High Frequency Chest Wall Oscillation in a Non-Invasive Ventilation Dependent Patient with Type 1 Spinal Muscular Atrophy. Resp Care 2011;56:1840-1843


DISCLOSURE: The following authors have nothing to disclose: Sonal Malhotra, Dr. Robert Kaslowsky
CASE REPORT FOR CHEST CUIRASS IN TODDLER WITH DIAPHRAGM WEAKNESS POST HEART TRANSPLANT.
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Introduction: Diaphragm weakness/paralysis can occur in patients using the Berlin Heart. The Berlin heart is used to assist the heart in maintaining adequate cardiac output or if it cannot adequately provide oxygenated blood to vital organs. The insertion of the device requires the cannulas to be placed through the diaphragms to get to the heart which can lead to diaphragm weakness/paralysis after removal. It is intended to provide cardiac support to the heart for patients awaiting heart transplant. Biphasic Cuirass Ventilation (BCV) is the ideal mode of ventilation for patients suffering muscle weakness. It is a noninvasive way to actively control both phases of the respiratory cycle. It can actually improve and redevelop the respiratory muscles weakened due to respiratory failure. IRB determination was that this case was not research and therefore not subject to IRB review. Case Summary: The patient was a 2 year old with a complex history that began with viral myocarditis. The patient underwent VA ECMO and was placed on a Berlin heart until time of heart transplant. The patient suffered from diaphragm weakness due to previous Berlin heart placement. The patient had several admissions for recurring pneumonia and chronic hypercarbia that required multiple intubations. It was decided to place the child on Biphasic Cuirass Ventilation via the Hayek RTX Ventilator prior to extubation. The initial settings were control mode rate of 20, -12/+3 while sleeping and CNEP-8 cm while awake. The patient received CPAP with Pressure Support via conventional ventilator. After several hours and comfort achieved on the Chest Cuirass the patient was extubated. The secretion clearance mode was also used on this patient to help generate a cough and maintain lung clearance. The patient remained on the chest cuirass for several months as an inpatient. During this time the patient transitioned to up to 4 hours a day off the device and discharged home on 14, -14/+3 settings. Discussion: Biphasic Cuirass Ventilation (BCV) can be a lower cost and noninvasive alternative to tracheostomy for some patients. Compared to other types of noninvasive ventilators BCV is easily fitted to small children and does not require sedation. More information and education is needed concerning the availability of the device as an alternative to tracheostomy in some patients.
HEMODYNAMIC CHANGES INDUCED BY CONTINUOUS CUIRASS NEGATIVE PRESSURE IN PATIENTS WITH FONTAN CIRCULATION

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INTRODUCTION: Early extubation in patients with Fontan circulation is generally advocated because spontaneous respiration increases systemic venous return and cardiac output. However, there are patients who need positive pressure ventilation because of delayed recovery from anesthesia due to residual opioids or sedatives, hypothermia, etc., after the Fontan procedure. Continuous cuirass negative pressure (CNPV) has been shown to attenuate the negative effects of positive pressure ventilation on circulation in adult cardiac patients. Thus, we hypothesized that CNPV would augment cardiac output in patients with Fontan circulation as shown in normal circulation. We hereby examined the effect of CNPV in combination with positive pressure ventilation on hemodynamics after the Fontan procedure.

METHODS: With approval of institutional review board and adherence to the Declaration of Helsinki, adult patients who underwent the Fontan operation between Dec 2009 and Dec 2013 were included in the study. All patients were transferred to the ICU with their trachea intubated and received positive pressure support (PS: 5 cmH2O) with positive end-expiratory pressure (3-5 cmH2O) under spontaneous breathing postoperatively. Synchronized intermittent mandatory ventilation was provided to avoid hypercapnia if necessary (3-8/min). Continuous cuirass negative pressure ventilation (−10-15 cmH2O) was started three hours after the admission to the ICU. CNPV was continued for 12-24 hours after the extubation. Cardiac index (CI) and central venous oxygen saturation (ScvO2) were monitored by FloTrac sensor and PreSep oximetry catheter (Edwards Lifesciences, CA, USA) continuously through the surgery and postoperative period. CI and ScvO2 were compared between pre- and post-CNPV periods. Data were analyzed with Kruskal-Wallis H-test followed by Mann-Whitney U-test with Bonferroni correction where applicable. P value less than 0.05 was considered significant.

RESULTS: Five patients were included in the study. Mean CI before and after CNPV were 1.9 ± 0.3 and 2.5 ± 0.2 (L/min/m²), respectively. Accordingly, ScvO2 increased after the initiation of CNPV significantly (52 ± 2 vs. 65 ± 4%). These hemodynamic changes may indicate CNPV augments cardiac output and improves oxygen delivery.

CONCLUSIONS: CNPV augmented cardiac output even in combination with positive pressure ventilation and improved oxygen delivery. Continuous cuirass negative pressure ventilation is effective to increase cardiac output and to improve oxygen delivery in patients with the Fontan circulation.

REFERENCES:
There are now over 200 Publications on the use, efficacy and advantages of BCV in a wide variety of clinical settings.