External Chest Compression in the Management of Acute Severe Asthma—A Technique in Search of Evidence

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Keywords: asthma; chest, compression of; life support; mechanical

Abbreviations:
MECC = mechanical external chest compression

Paper invited by Editor-in-Chief

Abstract
Compelling anecdotal evidence exists for the potentially lifesaving benefits of mechanical external chest compression (MECC), but no published trials of the technique exist. The history and technique for MECC are discussed and illustrated by a case report. Although the technique is not discussed in the Resuscitation Guideline 2000, and the need for it within the intensive care unit has reduced, the use of MECC will have its greatest impact when initiated in the prehospital setting for patients suffering from severe, sudden-onset, asphyxic asthma.

Fisher MM, Whaley AP, Pye Roger R : External chest compression in the management of acute severe asthma—A technique in search of evidence. ***Prehosp Disast Med*** **2001;16(3):83–86.**

Introduction

The use of mechanical external chest compression (MECC) to facilitate expiration in acute bronchial asthma has been taught and used for many years. Those who use it are convinced of its benefits. There are no published trials of the technique in animals or humans, randomised or otherwise.

There is a rational basis for its use and success as a supportive measure in acute, severe life-threatening asthma. Further, we believe that compelling anecdotal evidence exists for the potentially lifesaving benefits of MECC.

Case Report

A 27 year-old female with a history of mild asthma treated with salbutamol nebuliser developed a mild cough, but was able to perform her exercise regime at a gymnasium. She went to bed feeling well, but awoke suddenly with rapidly progressing dyspnoea.

She told her partner that she could not breathe, and he called for an ambulance. Shortly after this, she lost consciousness, stopped breathing, and became cyanosed, and her partner commenced mouth-to-mouth resuscitation. When ambulance officers arrived, she had faint audible breath sounds, still was cyanosed, and they commenced artificial ventilation by mask, manual external chest compression (MECC), administered salbutamol by nebuliser, and called for paramedic support. The paramedics, who were unable to intubate her, administered epinephrine intravenously according to their protocol, and transported her to hospital using mask ventilation and MECC. The time from commencement of ventilation to arrival was 50 minutes.

In the Emergency Department, she was intubated following neuromuscular blockade, but her lungs remained very difficult to inflate, and she did not exhale when inflation was ceased. Her admission arterial blood gases (FiO_2 = 1.0) were: pH = 6.75; $PaCO_2$ = 188 mmHg; PaO_2 = 328 mmHg; bicarbonate = 26 mmol/l; and base deficit = 15 mmol/l. She received boluses and then an infusion

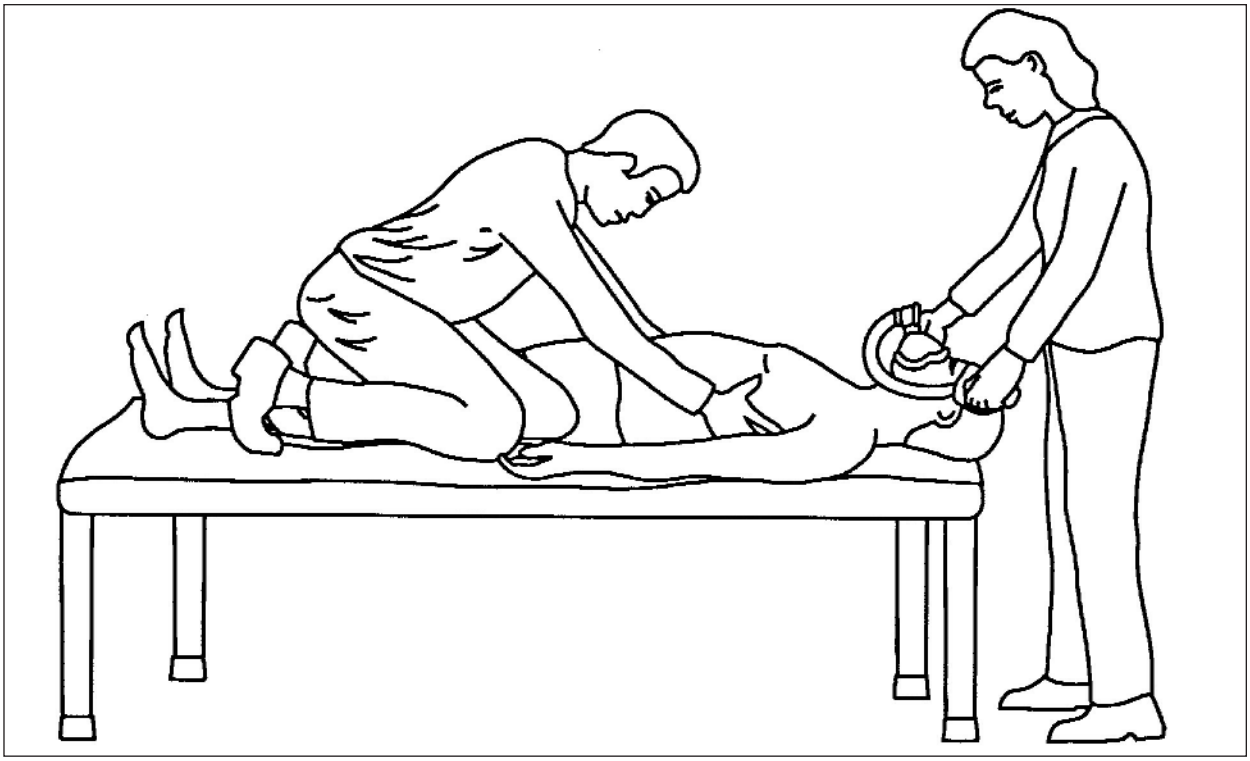

Figure 1—Application of mechanical external chest compression (MECC) for a to spontaneously breathing patient at end expiration

of intravenous epinephrine, a salbutamol infusion, and hydrocortisone, but was unable to be ventilated mechanically. She received a intravenous bolus dose of ketamine and nebulised salbutamol while two-person MECC was applied during expiration using mechanical ventilation at a rate of 5–8 breaths per minute for 40 minutes. Over this time period, manual ventilation became progressively less difficult and compliance improved. The patient was transferred safely to an Intensive Care Unit, and ventilated mechanically. Her condition improved progressively over the next eight hours. She was extubated 11 hours after intubation, and discharged from the hospital without adverse neurological sequelae four days later.

This case clearly illustrates the frightening condition of hyperacute, life-threatening asthma. While all the treatment instituted contributed to saving this patient's life, we would suggest that MECC instituted by both ambulance and medical personnel significantly contributed to life-support during resuscitation. This facilitated ventilation, particularly expiration, as well as enhancing the delivery of inhaled ß-agonist. The three doctors and two nurses involved in the resuscitation in the Emergency Department were impressed by the improvement associated with the use of MECC.

History

The origins of mechanical external chest compression in the treatment of patients with sudden-onset, severe bronchospasm are unknown. The first mention of endeavours to empty the lungs by compression was by Smolnikoff[1] from Moscow in 1960, who described three cases of "total bronchospasm". In one case, severe bronchospasm occurred during premedication and subsequent thoracotomy, and two cases during induction of anaesthesia for thoracotomy. The first two patients died and at postmortem, they observed "grossly distended lungs" that would not deflate. In the third case, the chest was opened, and the surgeon manually deflated the distended lungs.

Watt[2] was the first to advocate the technique in the literature. He made the point that if an open, flexible vessel is compressed, the content (air) is expelled. As the respiratory muscles are at a mechanical disadvantage in the hyperinflated chest, external chest compression not only aids expiration by expelling air, but also returns the chest to a lower volume allowing more efficient ventilation. The Heimlich Organisation has advocated the use of "diaphragm thrusts" in asthma to assist expiration and possibly clear mucus plugs. In the experimental studies of chest compression in hyperventilated dog model, it was shown that abdominal compression was as effective as chest compression in reducing end expiratory volume, but with less effect on cardiac function.[3]

Technique

Paramedics in New South Wales apply MECC to spontaneously breathing patients at end-expiration. In the ventilated patient, MECC is applied at the end of inspiration if there is minimal or no expiration, or at the end of expiration if it is desired to increase the expiratory volume. In both cases, the operator places her/his hands on either side

of the lower chest wall, and applies a firm, sustained squeeze during expiration. This may be done from behind or beside the patient, or by straddling a supine patient (Figure 1).

Logical Basis

We have advocated the use of external chest compression to assist expiration in cases of very severe asthma, in particular, cases of hyperacute bronchospasm or "sudden asphyxia asthma". This has been described as a separate subgroup of asthmatic patients who may not have a history of previous severe asthma requiring hospitalisation.[4-6] These patients experience very sudden onset of severe bronchospasm that may result in cardiorespiratory arrest and either death or subsequent hypoxic brain injury before reaching hospital. Those patients who do reach the hospital often are extremely difficult to ventilate with high airway pressures and hypercarbia. Eason *et al*[7] observed that treatment initially was very difficult, followed by rapid resolution. In these cases, the trigger is likely to be exposure to an allergen or stress and bronchospasm rather than mucus plugging as the predominant pathology. The MECC appears to benefit this group of patients most, preventing early cardiorespiratory arrest.

Exhalation is passive in health. In severe asthma, primary and accessory muscles of ventilation become important in active exhalation. When exhaustion or loss of consciousness occurs, the active efforts to exhale may cease. If the elastic recoil of the lungs and chest wall is insufficient to overcome the airways resistance, there may be no exhalation. Artificial ventilation will rapidly increase the over-distension of the lungs by "stacking" of breaths, producing barotrauma, cardiac tamponade, and hypotensive cardiac arrest.[8] It is under these circumstances that we have advocated assisting exhalation by squeezing the chest wall at the end of inspiration, assisting in movement of air out of the lungs. This also returns the chest wall to a lower volume and improves the mechanical function of the respiratory muscles by shortening their length.

Does It Work?

Our own efforts to validate the technique have been thwarted by changes in the intensive care epidemiology of acute asthma. In the 1970s and 1980s, we ventilated 20 to 30 asthmatics a year. Today, we ventilate three to four each year. These changes may be attributable to improved education and care in outpatient asthmatics.

Extreme cases of asthma, particularly those rapid onset cases were relatively common, and in the past, we have put three asthmatics that we could not ventilate mechanically on cardiopulmonary bypass. In the last 15 years, we have not seen anyone for whom we needed to consider the use of MECC.

Paramedic Management of Asthma

Ludwig Engel verified that asthmatic patients with histamine-induced bronchospasm had subjective feelings of improvement when external chest compression was applied, although he found no changes in lung volumes. It frequently is reported by New South Wales paramedics, that spontaneously breathing asthmatics experience a sense of easier breathing when the chest wall is compressed throughout or at the end of expiration and ask for compression to be reapplied when it is ceased.

If artificial ventilation is applied in severe bronchospasm, gas trapping may become severe and lead to cardiac tamponade or barotrauma. Our observations, when external compression is applied to a ventilated asthmatic, are a measurable increase in gas flow if pressure is applied during or at the end of expiration. Subsequent inflations reach the same tidal volume at lower peak pressure than the previous breath. The lower peak pressure is maintained while the compressions continue, and when stopped, the peak pressure rises and the extra expiratory gas flow at end expiration ceases. Cardiac output does not alter unless excessive pressure is applied.

There are three studies relating to the use of external chest compression during severe asthma. In a study of 49 patients with asthma treated by New South Wales paramedics, the paramedic evaluation of the technique has been that its use was lifesaving in 15 and effective in another 26.[11] In a study of 31 patients, 23 with respiratory arrest and 8 with cardiac arrest, expiratory chest compression was assessed as making artificial ventilation possible. This study may simply reflect paramedics' belief in the value of their protocols or be a tribute to their overall skills and training. However, doctors who have used the technique, particularly in the "unventilateable patient" demonstrate similar faith. New South Wales paramedic protocols include use of inhaled salbutamol, intravenous epinephrine, intubation, and external chest compression.

The technique was studied in experimental and a clinical studies by Van de Tow and colleagues. The dog study[3] mentioned previously was performed in a hyperinflated, mechanically ventilated model, and demonstrated that rib cage compression resulted in exacerbation of a decreased cardiac output, which was attenuated by abdominal compression. Both abdominal and chest compression increased mean expiratory pleural pressure and reduced expiratory lung volume. The study was well-performed, but the relevance of the hyperinflation model (with normal airways resistance, particularly expiratory resistance) to the practical use of the technique is questioned.

In a second study,[9] four mechanically ventilated patients were studied with manual compressions applied to the chest wall for two or three minutes. There were no benefits in any of the measured parameters or detrimental effects. These patients already had been ventilated in intensive care unit for 18–46 hours, and were stable with the technique applied for 2–3 minutes only. This is not the same clinical setting in which MECC previously has been advocated.

The current place of external chest compression in asthma remains that it is a technique that appears to be lifesaving under extreme conditions, and patients express relief under milder symptoms, but without any demonstrable benefit. The circumstances under which the technique has been advocated by our group, namely when there is no or minimal expiration occurring, has not been widely adopted, and is not mentioned in the Resuscitation Guideline 2000.[10] The MECC should be thought of as replacing or

delaying conventional therapies. It may assist in supporting ventilation until bronchodilating and other therapies can become effective. It may be that now we have become bolder with slow respiratory rates and permissive hypercarbia, the perceived need for such assistance within the intensive care unit has reduced. However, deaths that occur from sudden onset, asphyxic asthma are most common before the affected patient reaches a hospital. Thus, currently, the use of the MECC will have its greatest impact when initiated in the prehospital setting in patients suffering from severe, sudden-onset, asphyxic asthma.

Conclusion

The benefits of MECC in acute severe asthma have not been formally validated, although compelling anecdotal evidence exists. It is our view that the MECC should be added to the well-recognised supportive treatment strategies applied to acute near-fatal asthma. The use in the prehospital setting has a place as a lifesaving technique, as it is simple, requires no special equipment, and is reported to work faster than any drug. Certainly, it may not only allow time for drug therapy to act, but facilitate its delivery by improving lung mechanics and allowing more normal tidal volumes.

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