Extracorporeal membrane oxygenation as emergency treatment for life-threatening acute severe asthma

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Summary: We report a case of acute severe asthma that was resistant to full medical treatment, mechanical ventilation and halothane inhalation. Because a fatal outcome appeared likely extracorporeal membrane oxygenation, involving partial cardiac bypass, using femoral artery and femoral vein cannulation was instituted as an urgent measure. The patient then made a satisfactory recovery.

Introduction

Extracorporeal membrane oxygenation involving total cardiac bypass is in widespread use during cardiac surgery. The technique has been reported on one previous occasion for a patient with acute asthma (MacDonnell et al., 1981), with a successful outcome, but has an uncertain role in acute respiratory failure (Editorial, 1980). The most severe cases of acute asthma, unresponsive to full conventional treatment with bronchodilators and corticosteroids will usually respond to artificial ventilation. If not, then inhalational anaesthetic drugs may prove beneficial, such as halothane (Raine et al., 1981; Schwartz, 1984) or ether (Robertson et al., 1985). It might be expected that extracorporeal membrane oxygenation would relieve the lungs of their primary function of gas exchange, whilst allowing the characteristic pathological changes of acute asthma to gradually respond to conventional measures.

Case report

A 27 year old woman with a 12 year history of asthma and with three previous hospital admissions for severe episodes, suddenly developed wheezing after a respiratory infection and was taken to the casualty department. Her usual medication was oral aminophylline with inhaled salbutamol and beclomethasone. She was in respiratory distress with a tachycardia (140/min) and pulsus paradoxus (35 mmHg). Initial blood gas measurements on 35% oxygen were $P_{aO_2}$ 11.1 kPa, $P_{aCO_2}$ 9.9 kPa and pH 7.10. A chest X-ray showed no evidence of a pneumothorax. She was initially treated with intravenous fluids, steroids and aminophylline, oxygen and nebulised salbutamol and ipratropium in maximal doses. One hour later on a medical ward her clinical condition had deteriorated and the $P_{aCO_2}$ had risen to 11.8 kPa. She was transferred to the intensive care unit for mechanical ventilation. The inspiratory airway pressures generated were high and the $P_{aCO_2}$ did not subside (Figure 1). An aminophylline infusion was given so that the serum theophylline level was maintained at the upper limit of the therapeutic range. High doses of steroids were given (1200 mg hydrocortisone in the first 24 hours) plus high dose intravenous and nebulised salbutamol. Despite these measures and many adjustments of the ventilator the $P_{aCO_2}$ remained high. The pH remained low (range 7.0 to 7.17) despite three separate intravenous 50 ml doses of 8.4% bicarbonate. The patient developed a fixed dilated pupil, improving after mannitol. The inspiratory airway pressure gradually rose to 85 cm H$_2$O and the patient developed a pneumomediastinum and surgical emphysema. Halothane was given (the concentration being titrated to maintain a systolic blood pressure of 90 mmHg), without benefit.

Extracorporeal membrane oxygenation was instituted on the intensive care unit as an emergency, with cannulation of the right femoral artery and vein (venoarterial perfusion) and routine heparinisation. The $P_{aCO_2}$ immediately fell to normal. On partial bypass the ventilator was adjusted to ensure that the pressure did not rise above 40 cm H$_2$O. An oxygen/air mixture was used to remove the carbon dioxide and maintain oxygenation. Later halothane was added to the bypass with the aim of reducing the degree of bronchospasm. After stabilization bronchial lavage was performed. Extracorporeal respiratory gas exchange was main-
tained for 17 hours. The procedure was complicated by anaemia, transient thrombocytopenia and a deep vein thrombosis. The patient was extubated 10 hours after membrane oxygenation was discontinued (43 hours after admission). Later there was evidence of neurological deficit in the leg attributed to haematoma formation and entrapment neuropathy, which is improving. Otherwise her recovery was complete.

Discussion

A significant number of deaths from acute severe asthma still occur in the United Kingdom (Office of Population Censuses and Surveys, Mortality Statistics). Most episodes of asthma are controlled with corticosteroids and bronchodilators, such as beta-adrenergic receptor agonists and theophyllines. Few asthmatics require mechanical ventilation, but this group of patients is associated with a substantial mortality (Dales & Munt, 1984). Additional measures have been described such as bronchial lavage and the addition of anaesthetic agents, notably halothane (Raine et al., 1981; Schwartz, 1984). Halothane acts on bronchial smooth muscle causing dilatation (Aviado, 1975), but also acts adversely on the myocardium causing myocardial depression and arrhythmias (O'Rourke & Crane, 1982). Ether may be more effective (Robertson et al., 1985) but poses a significant risk of explosion and flammability. Of necessity most of these additional measures have been described by case reports of small numbers of patients, rather than by controlled trials.

Extracorporeal respiratory gas exchange utilizes membrane artificial lungs and one or a combination of two essential circulatory routes, namely vein to vein (veno-venous perfusion) or vein to artery (veno-arterial perfusion). Both routes have positive and negative features. Veno-arterial perfusion is more commonly used although more difficult technically to institute as large artery cannulation is required. It has the advantages of reducing pulmonary artery blood flow and pressure, producing greater extracorporeal blood flow rates and filtering any emboli generated in the systemic circulation. Reduction of the pulmonary arterial pressure improves the ratio of ventilation to perfusion in the distressed lungs, enabling better oxygenation of the blood flowing through them. Veno-venous perfusion does not decrease pulmonary artery blood flow or pressure and any emboli generated become trapped in the already compromised lungs. Veno-venous perfusion does however have the advantage of distributing oxygenated blood returned to the body physiologically by the left ventricle. The major complications of extracorporeal membrane oxygenation are well recognized and reversible, and include haemorrhage and infection. Haemorrhage may be due to the administration of heparin to prevent clotting in the extracorporeal circuit, plus the invariable thrombocytopenia produced by bypass (Hill et al., 1972).

The use of extracorporeal membrane oxygenation in acute respiratory failure is uncertain (Editorial, 1980), but it has proved valuable for central airways obstruction by tracheal tumours (Wilson et al., 1984). We have found only one previous report in the world
literature of the use of extracorporeal membrane oxygenation in acute, severe asthma where the patient survived (MacDonnell et al., 1981). Despite this lack of experience with the technique in severe cases of asthma, it has been recommended as a last resort measure when all else fails (Dales & Munt, 1984).

Our patient failed to respond to maximal conventional therapy. An adequate level of oxygenation was only achieved by giving high inspired concentrations (45%). The surprisingly persistent carbon dioxide retention, in the face of mechanical ventilation, probably indicated severe ventilation and perfusion imbalance from small airways occlusion. Faced with an increasing PaCO₂ and indirect evidence of raised intracranial pressure plus a rising airways pressure and evidence of early barotrauma, we resorted to extracorporeal membrane oxygenation, and believe it saved the life of the patient. Extracorporeal gas exchange relieved the lungs of their primary function whilst allowing time for the underlying pathological changes of the asthma attack to abate. We would not advocate indiscriminate use of this technique which can only be safely undertaken by experienced operators, but would suggest it as a last resort to physicians faced with desperately ill and deteriorating patients.

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References


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