

Low-flow veno-venous extracorporeal carbon dioxide removal in the management of severe status asthmatics: a case report

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Abstract

Status asthmaticus is a life-threatening condition that requires intensive care management. Most of these patients have severe hypercapnic acidosis that requires lung protective mechanical ventilation. A small proportion of these patients do not respond to conventional lung protective mechanical ventilation or pharmacotherapy. Such patients have an increased mortality and morbidity. Successful use of extracorporeal membrane oxygenation (ECMO) is reported in such patients. However, the use of ECMO is invasive with its associated morbidity and is limited to specialised centres. In this report, we report the use of a novel, minimally invasive, low-flow extracorporeal carbon dioxide removal device in management of severe hypercapnic acidosis in a patient with life threatening status asthmaticus.

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Key words

extracorporeal – hypercapnia – respiratory acidosis – status asthmatics

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Ethics

The Human Research and Ethics Committee of Peninsula Health approved the use of Hemolung in our intensive care unit. Approval was also obtained from the Therapeutic Goods Administration (TGA) Australia for using Hemolung. Consent from the patient was obtained to allow reporting of this case.

Conflict of interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

Introduction

Status asthmaticus, or acute severe asthma, is the term used to refer to an exacerbation of asthma that does not respond to usual pharmacotherapy. Patients with severe asthma are often admitted to intensive care units

(ICUs) for observation and management that may include non-invasive mechanical ventilation. However, a small proportion do not respond to these measures and will require invasive mechanical ventilation (IMV). Although precise epidemiology figures are lacking, it is estimated that about 30% of medical ICU

admissions for acute severe asthma require intubation and mechanical ventilation. The mortality of these patients on mechanical ventilation is increased with a mortality of 8% in published studies (1). Several ventilator strategies have been adopted to help minimise complications such as barotrauma and auto-positive end-expiratory pressure, leading to dynamic hyperinflation. While these strategies have reduced these complications, they are not always effective. Extracorporeal membrane oxygenation as an adjunct to mechanical ventilation for status asthmaticus was first reported in 1981 (2), and a number of subsequent reports have shown positive outcomes with this therapy (3–5).

We report a novel minimally invasive veno-venous extracorporeal carbon dioxide removal (ECCO₂R) technique that was used in treating a patient with life-threatening, refractory status asthmatics when mechanical ventilation was unsuccessful.

Case report

A 44-year-old male with a history of asthma presented to his general practitioner with acute shortness of breath. His asthma had been well controlled in the past, and he had not been previously admitted to hospital with an exacerbation of asthma. He was a known smoker and had experienced symptoms suggestive flu for a few days prior to presentation. After clinical examination, his general practitioner suspected an exacerbation of asthma with a possible pneumothorax. Because of severe dyspnoea and significant desaturation, the patient was immediately transferred to the Frankston Hospital emergency department (ED) via ambulance. Shortly after presentation to the ED, he suffered respiratory arrest. A short period of resuscitation included endotracheal intubation, IMV and decompression of a tension pneumothorax via placement of a left chest drain. Following a brief period of improvement, he again deteriorated and a second tension pneumothorax was identified in the patient's right side, requiring placement of an additional chest drain. Admission to the ICU followed. While in intensive care, he required a third chest drain due to worsening pneumothorax in the right chest consequent to poor drainage of air from the existing chest drain.

Over the next 48 h in the ICU, the patient continued to deteriorate with the development of significant subcutaneous emphysema and ongoing air leaks. By the third day, he had become very difficult to ventilate with uncontrollable hypercapnia (arterial CO₂ tension, PaCO₂ was 73 mmHg, with pH 7.22) and worsening

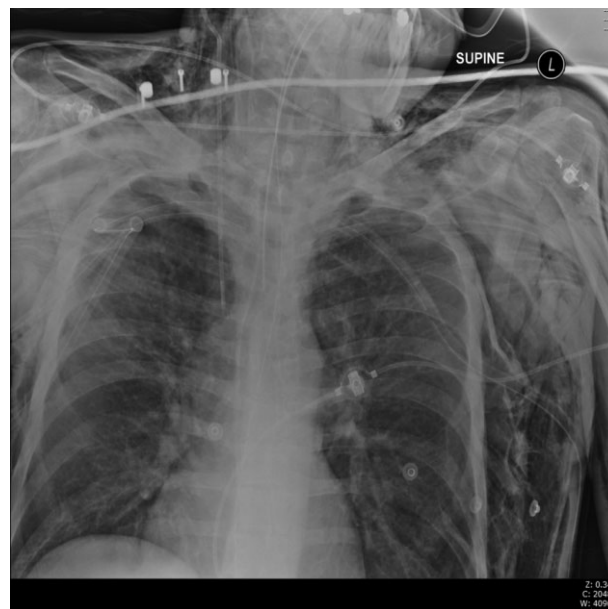


Figure 1. Chest X ray prior to initiation of Hemolung showing extensive surgical emphysema and multiple chest drains.

surgical emphysema (Fig. 1) despite optimal medical management including the use of corticosteroids, nebulised (salbutamol and ipratropium) and intravenous bronchodilators (aminophylline), magnesium, ketamine and muscle relaxants. ECCO₂R was indicated to control the hypercapnia and facilitate de-escalation of IMV.

ECCO₂R with Hemolung RAS[®] (ALung Technologies, Inc., Pittsburgh, PA, USA) was initiated to facilitate carbon dioxide clearance and reduce barotrauma. A detailed description of Hemolung has been published previously (6, 7). The application of this device consisted of a 15.5 French double lumen catheter, a controller and an integrated pump/gas-exchange cartridge. The right internal jugular vein was cannulated under ultrasound guidance. Intravenous heparin (80 U/Kg) was given to aim for limited heparinisation (aiming for an ACT of 150 to 180 s). The Hemolung RAS circuit was then connected to the catheter, and ECCO₂R was initiated. Extracorporeal blood flow was established at 470 mL/min, and the sweep gas was gradually increased to 10 L/min to provide ECCO₂R of approximately 100 mL/min as measured by the Hemolung Controller (Table 1). Following the introduction of Hemolung, it was possible to decrease the support on mechanical ventilation while maintaining satisfactory gas exchange and allowing to withdraw the use of muscle relaxants. Excellent clearance of carbon dioxide was achieved through the extracorporeal device.

Table 1. Blood gasses and Hemolung RAS parameters

	Before initiation	At initiation	1 h	6 h	Day 1	Day 2	Day 3	At removal	24 h post-removal
pH	7.22	7.24	7.28	7.33	7.31	7.39	7.44	7.42	7.39
PaO ₂ (mmHg)	96	92.5	77.1	65.9	62.1	66.9	87.4	76.9	77.2
PaCO ₂ (mmHg)	73	68.1	60.6	53.6	57.5	64.7	57.1	45.2	60
HCO ₃	25	25.1	25.3	28.9	26.6	36	38.5	34.4	34
Base excess	0.6	0.6	1.0	2.0	2.6	12.9	14.7	8.8	9.2
SaO ₂	98	97.1	95.4	95.3	92.9	94.9	98.7	96.1	95
FiO ₂	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.55	0.4
Mode of mechanical ventilation	Bi-level	Bi-level	Bi-level	Bi-level	Bi-level	Bi-level	SIMV VC	SIMV VC	SIMV VC
Minute ventilation (L)	5.5	5.7	5.1	5.2	4.9	4.8	5.1	8.9	8.4
Peak inspiratory pressures	34	34	34	32	32	26	27	28	30
Tidal vol	460	460	450	450	449	455	420	497	480
Resp rate	12	12	12	12	10	10	14	18	18
Hemolung flow (mL/min)		470	540	540	540	530	550	540	
Hemolung sweep (L/min)		6	10	10	10	10	10	4.1	
Carbon dioxide clearance (mL/min)		75	105	94	100	105	101	81	
Heart rate	77	75	65	65	67	90	80	100	105
Mean blood pressure (mmHg)	78	85	100	92	95	105	90	92	75

Tidal volume and minute ventilation may not be accurate because of air leaks from three chest drains.

SIMV, synchronised intermittent mandatory ventilation; VC, volume control.

Over the next 48 h, the patient showed signs of improvement with a substantial decrease in the surgical emphysema. However, the air leaks from the three chest drains continued. On the third day on ECCO₂R, the chest drain on the left side blocked and the drain was replaced to resolve another tension pneumothorax. Bleeding within the chest was noted as evidenced by a fall in haemoglobin and haziness on the chest X-ray. This was managed by blood transfusion (three units) and a reduction of systemic anticoagulation. ECCO₂R was continued for a total of 7 days until respiratory function had substantially improved. Following the discontinuation of ECCO₂R, the patient had video-assisted thoracoscopic surgery for evacuation of haematoma in left pleural cavity and was tracheostomised to assist in weaning from IMV. He was weaned off from mechanical ventilation and was discharged to a ward after 23 days of ICU stay. He was transferred to a rehabilitation facility 3 days later and ultimately discharged home.

Discussion

We report the successful use of a novel low flow ECCO₂R device in the management of severe hypercapnia and barotrauma in a patient with life threatening status asthmaticus. In most cases of bron-

chial asthma, maintenance of oxygenation is not difficult. However, hypercapnia secondary to alveolar hypoventilation and gas trapping cause severe respiratory acidosis and may increase mortality and morbidity.

This patient had severe asthma that precipitated respiratory arrest soon after arrival to our ED. The asthma was resistant to conservative measure including the use of bronchodilators, steroids and lung protective ventilation. The barotrauma this patient sustained was so profound that it ultimately precluded mechanical ventilation, making ECCO₂R the only remaining treatment option. Extracorporeal membrane oxygenation (ECMO) may have been beneficial in this patient, and several reports have confirmed the use of ECMO in managing severe hypercapnic respiratory failure (2, 8, 9). Furthermore, the use of ECMO is increasing, and the complications associated with the use of ECMO is reduced with modern ECMO cannulae and circuits (10). Nevertheless, the use of ECMO is still limited to specialised centres and requires a multidisciplinary approach for a successful outcome. The availability of ECMO in only specialised centres usually requires the transfer of patients who have severe respiratory failure with associated risks.

Successful reports of other less invasive devices such as Novalung iLA (Novalung GmbH, Heilbronn, Germany) were reported (4, 5). Novalung iLA is driven

by the patient's cardiac output and therefore does not require extracorporeal pump assistance. However, the use of such devices implies a more invasive approach than the use of Hemolung as it requires cannulation of femoral artery. The reported rate of lower limb ischemia is over 24%, making this device less attractive in the management of hypercapnic respiratory failure (11). These devices are also not indicated in patients with inadequate cardiac output.

Contrary to these devices, the use of Hemolung appears to be minimally invasive with excellent carbon dioxide clearance. It does not require larger cannulae as for ECMO or arterial cannulation for iLA. However, Hemolung does not improve oxygenation. In status asthmaticus patients with severe hypoxemia, ECMO remains the only management option. The only complication we noted in our patient after initiation of Hemolung was a haemothorax occurring after drainage of a tension pneumothorax. As this was a medical emergency, it was not possible to reduce anticoagulation, which may have reduced the risk of haemothorax substantially.

To conclude, the use of low-flow venovenous ECCO₂R was successful in treating severe hypercapnia in our patient with status asthmatics. Such devices are simpler to use than ECMO and may reduce the need of ECMO in patients with severe hypercapnia. Awareness and appropriate use of such devices may improve the mortality and morbidity of patients with status asthmaticus.

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