Emergency use of extracorporeal membrane oxygenation for a foreign body obstructing the airway

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ABSTRACT

We report on the successful emergency use of extracorporeal membrane oxygenation to provide oxygenation and ventilation to a patient with life-threatening airway obstruction, and then facilitating the removal of a tracheal food bolus by rigid bronchoscopy.

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Foreign bodies in the respiratory tract are a common cause of morbidity and mortality, accounting for 7.8% of community injury deaths in Australia between 2004 and 2005.[1]

Occurrence is much less common in adults than in children, with people over 18 years of age accounting for only 20% of cases across all age groups. In adults, obstruction of the respiratory tract by a foreign body is most commonly secondary to unconscious accidental aspiration during sedation, intoxication, trauma, seizures, general anaesthesia or neurological disorders affecting the oropharynx, and its prevalence increases steadily with age after the sixth decade.[2,3] It is a potentially life-threatening event because of its potential to precipitate total airway obstruction. The patient described here has given consent for the publication of this case report.

Clinical record

A previously healthy 33-year-old man was found collapsed outside a restaurant where he had been dining. He had been drinking heavily and had just returned to the country on a long-haul flight. Bystanders were unable to feel a pulse and commenced cardiopulmonary resuscitation. When ambulance officers arrived they found a palpable pulse, but the man remained cyanotic and unresponsive (Glasgow Coma Score 3).

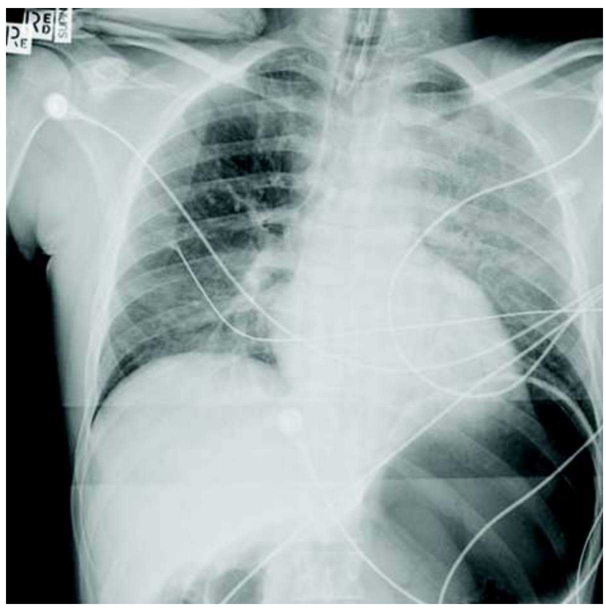
Bag-mask ventilation was ineffective, and on arrival in the emergency department the patient was intubated with thiopentone (100 mg) and suxamethonium (100 mg). However, ventilation remained poor, with very high airway pressures (requiring manual bag ventilation) and very small tidal volumes. The patient remained profoundly hypoxic (SpO_2 40%–60%), but was haemodynamically stable. Examination found reduced air entry on the left side, and a left needle thoracostomy was performed for suspected pneumothorax. However, there was no improvement in ventilation or pulse oximetry.

A chest x-ray initially showed only increased infiltrate on the left side and significant gastric distension (Figure 1) (on later review, an obstructed left main bronchus was also diagnosed). Transthoracic echocardiography, performed mainly to check for features of acute pulmonary embolus, revealed a normal heart.

Fibreoptic bronchoscopy was then performed through the endotracheal tube to look for infraglottic airway obstruction. A food bolus was observed completely obstructing the trachea. Suction was not available on the bronchoscope, and attempts to use suction via a suction catheter passed through the endotracheal tube were ineffective. At this point, the patient remained haemodynamically stable but was still profoundly hypoxic. Arterial blood gas measurements were pH 6.94, PCO_2 141 mmHg and PO_2 45 mmHg.

An urgent cardiothoracic surgical review was conducted, and the decision was made to institute venovenous extra-

Figure 1. Initial chest radiograph in the emergency department



corporeal membrane oxygenation (VV ECMO) in the emergency department to relieve the hypoxia and facilitate an urgent rigid bronchoscopy to remove the food bolus. A 23Fr drainage cannula was placed percutaneously in the inferior vena cava via the right femoral vein, and a 23Fr return cannula was placed percutaneously in the right atrium via the left femoral vein. The ECMO circuit consisted of Bioline-coated tubing (Maquet, Hirrlingen, Germany), a Rotaflow pump (Maquet) and a Quadrox D oxygenator (Maquet). The initial ECMO flow rate was 4.4 L/min. The decision to institute VV ECMO was made about 100 minutes after the patient's arrival in the emergency department, and ECMO was commenced 127 minutes after arrival. This was about 140 minutes after the patient was found collapsed outside the restaurant, and he had remained markedly cyanotic throughout this time. On initiating VV ECMO, SpO_2 increased from 75% to 95% and the patient's cyanosis resolved immediately.

The patient was then transferred to the operating theatre, the endotracheal tube was removed and rigid bronchoscopy performed. This confirmed the findings of the fibreoptic bronchoscopy, and large amounts of partially chewed steak were removed from the trachea and right main bronchus (Figure 2). Further food boluses were removed from the right main and branch bronchi with the fibreoptic bronchoscope. During the procedure, when gas exchange was maintained entirely with VV ECMO (no ventilation was attempted via the airway), arterial blood gas measurements showed pH 7.17, PCO_2 60 mmHg and PO_2 77 mmHg.

After removal of all visible fragments of the food bolus, the patient was reintubated. Ventilation without VV ECMO support was tried, but the patient's SpO_2 readings quickly dropped below 85%. VV ECMO was restarted and the patient was transferred to the intensive care unit, where lung rest ventilation was instituted (pressure control ventilation with inspiratory pressures of 25 cmH_2O, rate 10/min, positive end-expiratory pressure 12 cmH_2O, and FiO_2 0.5). The patient was actively cooled to 34°C for 24 hours because of concerns about neurological injury secondary to prolonged hypoxia.

The patient improved rapidly and was weaned from VV ECMO after 36 hours, extubated the same day and discharged to the ward on the following day. Examination of the patient on the ward revealed normal neurological function. The taking of a more detailed history revealed that he had taken diazepam during the long-haul flight to help him sleep and had been drinking during the day and at dinner. A urine drug screen was positive for benzodiazepines, and his blood alcohol level was 0.26%. The patient had little recollection of the dinner and did not remember aspirating the food bolus.

Figure 2. Retrieved foreign body

Follow-up after discharge found that the patient had rapidly returned to work, had no neurological injury and had only a mild impairment of exercise tolerance.

Discussion

There has been a significant increase in the use of ECMO at our institution over the past 5 years. This has been driven mainly by technical improvements in the current generation of ECMO circuits. The three key improvements have been the development of polymethylpentene oxygenators, the development of a third generation of centrifugal pumps, and the use of tip-to-tip heparin-coated circuits.[4-6]

There is an emerging evidence base for the use of ECMO in certain clinical settings. Firstly, the CESAR (Conventional Ventilatory Support versus ECMO for Severe Adult Respiratory Failure) trial has provided evidence for the use of VV ECMO in adults with severe acute respiratory distress syndrome.[7] Secondly, a recent large case series has provided evidence for the use of ECMO in cardiopulmonary resuscitation (CPR).[8] However, the application of ECMO to cases of airway obstruction has been limited.

Indeed, a literature search conducted using the search engines PubMed and Google Scholar (searching for the terms ECMO + foreign body; ECMO + airway obstruction; ECMO + critical airway; and an(a)esthesia + airway obstruction) revealed only one case report involving an adult, and no case reports of ECMO being used in an emergency situation.[9] However, the use of ECMO has been well described in the paediatric population for providing gas exchange in patients with airway obstruction for whom conventional ventilation techniques cannot provide adequate gas exchange.[3] Infraglottic airway obstruction due to foreign bodies is significantly more common in children, which may explain the increased use of ECMO in the paediatric population.[10,11]

A key reason for the limited use of ECMO in cases of acute, life-threatening airway obstruction is the time-limited nature of the condition. Our hospital has recently implemented an ECMO CPR program. Since the advent of this program, the time from decision to initiation of ECMO in cardiac arrest patients has been less than 30 minutes in all cases, whereas previously it had been up to 1–2 hours. This reduction in decision-to-initiation time has made the use of ECMO in life-threatening airway obstruction technically feasible. In the case described here, the patient had infraglottic airway obstruction, but the technique could potentially be used in cases of supraglottic airway obstruction (ie, cases in which patients can not be intubated or ventilated).

A major concern about the use of ECMO in life-threatening airway obstruction is the risk of severe hypoxic brain injury during the period of hypoxia prior to initiation of ECMO. The severity and duration of hypoxia that can be tolerated without neurological injury is unknown, and there is evidence of considerable variation between individuals.[12] This uncertainty will inevitably lead to cases of severe hypoxic brain injury when treating patients who have had significant episodes of hypoxia. Neurological injury was certainly a concern in our patient, given the duration and severity of his hypoxia and the possibility that he may have had a cardiac arrest before the arrival of ambulance officers.

There is now good evidence that hypothermia improves outcomes in comatose survivors of out-of-hospital cardiac arrests.[13] We chose to cool the patient to 34° C for 24 hours with the aim of reducing the risk of neurological injury, although recognising that the evidence base for hypothermia relates predominantly to cardiac arrests and not to severe hypoxia. A useful practical point to note is that the desired patient temperature can be achieved rapidly and maintained very accurately with ECMO (via the heat exchanger present in the ECMO circuit).

Looking to the future, VV ECMO may have an increasing role in highly selected cases of infra- and supraglottic airway obstruction at centres that have the capacity to establish ECMO rapidly.

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References

1 Australian Institute of Health and Welfare. Injury deaths, Australia 2004–05. Community injury. Canberra: AIHW, 2009. http://www.aihw.gov.au/publications/inj/injcat-127-10777/injcat-127-10777.pdf (accessed Oct 2010).
2 Boyd M, Chatterjee A, Chiles C, Chin R. Tracheobronchial foreign body aspiration in adults. *South Med J* 2009; 102: 171-4.
3 Baharloo F, Veyckemans F, Francis C, et al. Tracheobronchial foreign bodies; presentation and management in children and adults. *Chest* 1999; 115: 1357-62.
4 Khoshbin E, Roberts N, Harvey C, et al. Poly-methyl pentene oxygenators have improved gas exchange capability and reduced transfusion requirements in adult extracorporeal membrane oxygenation. *ASAIO J* 2005; 51: 281-7.
5 Moen O, Fosse E, Dregelid E, et al. Centrifugal pump and heparin coating improves cardiopulmonary bypass compatibility. *Ann Thorac Surg* 1996; 62: 1134-40.
6 Lawson D, Richard I, Cheifetz I, et al. Hemolytic characteristics of three commercially available centrifugal blood pumps. *Pediatr Crit Care Med* 2005; 6: 573-7.
7 Peek G, Mugford M, Tiruvoipati R, et al. Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation (CESAR): a multicentre randomised controlled trial. *Lancet* 2009; 374: 1351-63.
8 Chen Y, Lin J, Yu H, et al. Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis. *Lancet* 2008; 372: 554-61.
9 Chen A. ECMO-assisted rigid bronchoscopy for tracheal obstruction. *J Bronchol Intervent Pulmonol* 2009; 16: 296-7.
10 Mentzelopoulos SD, Tzoufi M. Anesthesia for tracheal and endobronchial interventions. *Curr Opin Anaesthesiol* 2002; 15: 85-94.
11 Farrell P. Rigid bronchoscopy for foreign body removal: anaesthesia and ventilation. *Paediatr Anaesth* 2004; 14: 84-9.
12 Simes D. Supplemental jet ventilation in a case of ARDS complicated by bronchopleural fistulae. *Crit Care Resusc* 2005; 7: 111-5.
13 Bernard S, Gray T, Buist M, et al. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. *N Engl J Med* 2002; 346: 557-63. ❑

Correction

It has come to our notice that Dr Brendan Smith was referred to as an "Associate Professor" in a recent letter sent to *CCR* (Vol. 12, No. 3, Sep 2010, page 210). However, information from Charles Sturt University (Associate Professor Lyn Angel, Head, School of Biomedical Sciences, and Chair, CSU Ethics Human Research Committee, Charles Sturt University) indicates that the correct title should have been "Adjunct Associate Professor". We wish to inform the readership of this error. ❑