Survey of adult extracorporeal membrane oxygenation (ECMO) practice and attitudes among Australian and New Zealand intensivists

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ABSTRACT

Objective: To gauge use of extracorporeal membrane oxygenation (ECMO) in Australian and New Zealand intensive care units, to investigate attitudes to and experience with ECMO, and to assess interest in contributing to a national database of ECMO use.

Methods: The survey was conducted by email in July 2004. A targeted cohort of ICUs across the two countries was chosen, comprising JFICM (Joint Faculty of Intensive Care Medicine) Approved Training Centres, and large regional and private institutions. Directors of the ICUs were invited to participate in the survey of department demographics, ECMO practice rates and experience, and attitudes to ECMO. The survey was registered (http://clinicaltrials.gov registration number NCT00157144), and local ethics approval was obtained.

Results: Response rate was 56% (39/70), with 49% of responses (19/39) from JFICM Approved Training Centres. ECMO practice in responding centres was low, with 69% (27/39) having managed no ECMO patients in the past year, and 62% (24/39) having managed none in the past 3 years. Only one centre had managed more than eight patients in the past year. Individual respondents had limited ECMO experience, with 56% (22/39) having *ever* managed two or fewer patients. The most common reasons given for not providing ECMO were lack of staff skill/training and lack of access to support services. Cost, high mortality and lack of evidence for ECMO efficacy were not regarded as significant factors preventing its use. Seventy-two per cent (28/39) of respondents supported ECMO use outside a randomised controlled trial, and 49% (19/39) would conduct ECMO at their own institution, while 74% (29/39) felt it a useful tool to facilitate transport to specialist centres.

Conclusion: ECMO use in Australian and New Zealand ICUs is limited, but there is support for its use among survey respondents. Lack of training and experience with ECMO may be restricting its use.

Crit Care Resusc 2008; 10: 42–46

Use of extracorporeal membrane oxygenation (ECMO) has shown a marked survival advantage in neonates with respiratory failure and is standard care for this group.[1] The role of this therapy in the adult population compared with best standard care is uncertain. It may be used for respiratory or cardiac support in patients with life-threatening cardiorespiratory failure.

The largest database for ECMO outcomes is run by the Extracorporeal Life Support Organization,[2] which began in 1989. This registry records more than 30 000 cases, with an overall 66% survival. Adult ECMO patients make up 5% of this total. Past randomised controlled trials (RCTs) of ECMO in adult respiratory failure[3,4] demonstrated high mortality and no survival benefit compared with standard medical therapy. Currently, a trial of ECMO for adults with respiratory failure is underway in the United Kingdom — the CESAR trial (Conventional Ventilation or ECMO for Severe Adult Respiratory Failure; http://www.cesar-trial.org). This is the largest ECMO trial to date and powered to detect a mortality difference, as well as quality of life and economic outcomes.

ECMO has been used for adults in Australia and New Zealand[5-12] with some success, but the extent and nature of its use in adults is unknown. The largest case series to date reported outcomes of 17 patients.[10] No regional standards for staffing, training and equipment exist for the long-term (days to weeks) application of this technology in the intensive care unit. Barriers to the implementation of ECMO in Australia and New Zealand are not known.

This study aimed:

- to gauge the use of ECMO in Australian and New Zealand intensive care departments over periods of 12 months and 3 years;
- to sample the attitudes toward ECMO practice and barriers preventing its use; and
- to assess interest in a prospective database of ECMO practice.

Methods

The survey contained epidemiological and attitudinal components, specifically addressing department demographics, ECMO practice rates and experience, and attitudes and barriers to ECMO. Questions were formulated based on the above objectives and emailed as data fields in Microsoft Excel format (Appendix 1). Respondents were required to select from a series of pre-determined epidemiological

Table 1. Number of respondents, by location and JFICM accreditation as training centre

State/country	Total respondents	JFICM ATC respondents*
Tasmania	3/3	1/2
Victoria	13/15	5/13
New South Wales	5/19	3/18
Australian Capital Territory	1/3	1/1
Queensland	9/11	3/10
Northern Territory	0/2	0/1
South Australia	1/5	1/3
Western Australia	1/5	1/3
New Zealand	6/7	4/6
Total	**39/70**	**19/57**

JFICM ATC = Joint Faculty of Intensive Care Medicine Approved Training Centre. * Proportion of JFICM ATCs that responded.

Figure 1. Use of ECMO in the past 12 months or 3 years in 39 intensive care units

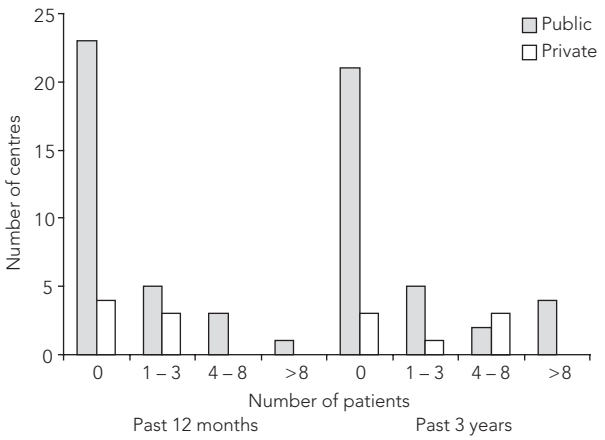
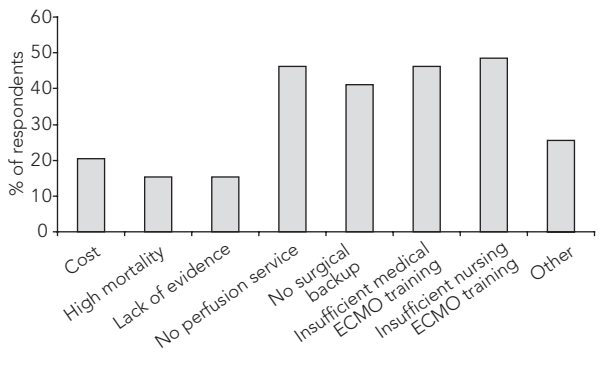


Figure 2. Perceived barriers to ECMO use among respondents from 39 intensive care units



ranges or attitudinal options. Closed questions were used to increase accuracy and minimise incomplete responses.[13] This method was selected to maximise sample size, reduce cost and allow for prompt data analysis and storage.[14] The trial was prospectively registered (http://clinicaltrials.gov registration number NCT00157144) and was approved by the local research and ethics committee (Alfred Research and Ethics Unit). Surveys were mailed out in July 2004. No incentives were provided for completing the survey.

Centres were selected from the Australian and New Zealand Intensive Care Society directory of adult intensive care departments. The directory contains contact details for directors of 199 high dependency/intensive care units in Australia and New Zealand. Emails were directed to intensive care departments accredited as Approved Training Centres by the Joint Faculty of Intensive Care Medicine (JFICM), and to those in large regional centres and major private hospitals. This cohort was deliberately targeted to maximise inclusion of centres most likely to be providing ECMO, and the survey was emailed specifically to directors as it was likely they would be most aware of departmental practices and attitudes to ECMO. Smaller centres, such as those in a rural and remote locations, and centres with only high-dependency facilities were not contacted. No centres contacted expressed any objection to participating, and no response was excluded from the analysis.

Initial responses were collected, errant emails were adjusted and sent again, and the Approved Training Centres listed on the JFICM website were specifically targeted in the subsequent distribution. For the purposes of this survey we defined centres as practising ECMO if they reported providing ECMO in the previous 3 years.

Results

Of 70 centres targeted, 39 responded, giving an overall response rate of 56%. The response rate by region is shown in Table 1. Forty-nine per cent of responses (19/39) were from JFICM Approved Training Centres. None of the surveys that were returned had incomplete data or omitted responses. Eighty-seven per cent (34/39) of responses were completed by the department director. Of the respondents, 82% (32/39) were from public intensive care departments and 18% (7/39) from private institutions. Sixty-nine per cent (27/39) of hospitals surveyed had 10 or fewer intensive care beds, while 28% (11/39) had 11–20 beds, and 3% (1/39) had more than 20 beds. Fifty-nine per cent (23/39) were staffed by zero to three full-time intensivists, 31% (12/39) by four to six, and 10% (4/39) by seven or more. Forty-one per cent (16/39) of respondents had access to a perfusion service (71% [5/7] of private and 34% [11/32] of public departments), and 44% were supported by a cardiothoracic

unit or surgeon (71% [5/7] of private and 37% [12/32] of public departments).

Thirty-eight per cent (15/39) of responding units had used ECMO in the previous 3 years: 11 were from public institutions and four were private centres (Figure 1). Twelve of the 15 (80%) reported having used ECMO in the previous 12 months.

The reported use of ECMO per annum in the 15 centres that practised ECMO was low, with only one reporting more than eight ECMO patients in the previous 12 months, and only four (27%) reporting that number in the previous 3 years.

Twenty-two (56%) of the 39 responding intensive care specialists recalled having managed two or fewer patients receiving ECMO, either during their intensive care fellowship training or after becoming consultants. Five (13%) recalled having managed more than 20 patients.

Seventy-two per cent (28/39) of respondents felt ECMO use should not be restricted to a multicentre RCT for specific conditions; 49% (19/39) would practise ECMO in their own institution, while 74% (29/39) believed ECMO could be used to facilitate patient transport to a specialty centre. Among respondents from the 15 departments that had managed ECMO patients in the previous 3 years, support for ECMO outside the context of an RCT increased to 87% (13/15), while 93% (14/15) felt ECMO was a useful tool for patient transport to a specialty centre. All departments with ECMO experience supported its use at their facility.

Stated barriers to ECMO use in public institutions were predominantly the lack of perfusion and cardiothoracic services and lack of adequate staff training. Private centres placed higher emphasis on cost, perceived high mortality and lack of evidence compared with public centres (Figure 2).

ECMO was more likely to be used in departments with access to a cardiothoracic surgeon or perfusion service. Of the centres practising ECMO, 87% (13/15) had access to both these supports, while 13% (2/15) reported practising without such supports in their hospital.

Support for ECMO data collection was high, with 82% of respondents (32/39) willing to contribute data in the event they used ECMO. In departments practising ECMO, 93% (14/15) supported collecting data for a prospective database.

Discussion

This targeted survey of 70 adult Australian and New Zealand ICUs, including all JFICM Approved Training Centres, as well as ICUs in large private hospitals and regional centres, had a response rate of 56%. Most responses were from ICU directors, and 49% were from JFICM-accredited training units. Responding centres were predominately from small and middle-sized metropolitan hospitals and larger regional hospitals and most were staffed by fewer than seven full-time intensivists. Only one large centre with more than 20 ICU beds responded. There was a Victorian and Queensland bias, with close to two-thirds of all responses coming from these states.

Among respondents, ECMO utilisation over the previous 3 years was 38% (15/39), despite only one ICU with more than 20 beds responding. According to our responses, ECMO was practised infrequently, in small numbers of patients, in numerous small to medium-sized units, and was more likely to be used in units with cardiothoracic and perfusion services. While this rate cannot be generalised beyond our targeted cohort, it is the first attempt to determine the incidence of ECMO use in the survey population of larger and accredited units. Unfortunately, ICUs with more than 20 beds were not adequately represented.

Over 70% of respondents supported the use of ECMO outside the context of an RCT despite most respondents coming from ICUs that did not practise ECMO, and the remainder not using ECMO frequently or having much experience of ECMO during their training. Almost half the respondents stated they would actually conduct ECMO at their own institution, and nearly three-quarters indicated they believed it would be a useful mode of support to facilitate transport from their own centre to a specialist centre.

This high level of support for the practice of ECMO among respondents could represent a selection bias, as directors with an interest in ECMO may have been more likely to respond. However, considering the low levels of stated experience with ECMO, our findings may indicate a broadly held view that ECMO does have a role in adult care despite the absence of evidence in support. As we did not assess respondents' knowledge of previous RCTs of adult ECMO,[3,4] we do not know whether they had considered the limitations of these studies.

The first multicentre RCT evaluating full ECMO support for respiratory failure used methods which differ from those considered standard in current practice.[3] Most importantly, veno–venous ECMO was not used, and all patients received veno–arterial ECMO as therapy for respiratory failure, with high-pressure ventilation to the lung continued during ECMO therapy. These practices are likely to have exacerbated lung injury. Finally, the incidence of anticoagulation-associated severe bleeding was regarded as high, and commencement of ECMO was considered to be late. Subsequent trials[4,15] examined partial extracorporeal veno–venous support in combination with a "lung rest strategy" for severe respiratory failure. Again in the setting of an RCT,[4] no survival benefit and a high rate of complications were observed with the use of partial extracorporeal sup-

port. No adult trials have examined veno–arterial ECMO for cardiac failure. It is possible that respondents were aware of the inadequacies of the previous trials and considered they therefore could not guide decisions on ECMO use in cardiac or respiratory failure.

The ongoing CESAR trial in the UK is examining the effect of ECMO in severe adult respiratory failure, defined by a Murray Score $\geqslant 3$[16] or severe uncompensated hypercapnia (pH < 7.20). The control-arm mortality of this group has been estimated to be 70%. Our survey did not examine the clinical criteria for considering ECMO. It is possible that the outcome of the CESAR trial, to be reported in 2008, could dramatically affect attitudes to adult respiratory ECMO.

Published local case series and case reports[5-12] of adult ECMO practice show a predominance of veno–arterial support for acute cardiac failure in the settings of postcardiac surgery, lung transplantation, overdose or sepsis. Cases of veno–venous ECMO for isolated respiratory failure are less common in these reports and were used in the setting of respiratory failure due to lung transplantation, pneumonia and pulmonary vasculitis. Our survey made no attempt to delineate the indications for ECMO or the form of ECMO used.

According to our survey, the most commonly selected barriers to ECMO provision in our region were lack of staff skills and training, and inability to access surgical and perfusion support. Cost, perceived high mortality and lack of evidence for ECMO efficacy were less often selected as barriers to ECMO implementation. High mortality and lack of evidence were both more prominent perceived barriers in the private sector. However, the number of private institutions surveyed was low in comparison with the number of public institutions.

While we can report the most prevalent reasons for not practising ECMO across the study population, we cannot quantify the degree to which these barriers contribute at an individual hospital or consultant level. It is possible that the incidence of ECMO practice could increase with further staff education and training, particularly in centres with access to cardiothoracic surgeons and perfusion services.

As with all surveys,[14] there is a potential for recall bias. Respondents who were involved in the use of ECMO for only a brief time or had a limited role in decision-making may not have considered this sufficient to qualify themselves as having "managed" an ECMO patient, leading to under-reporting. The survey could not easily define the term "management", and therefore cannot gauge the extent of respondents' clinical decision-making.

Internationally, the use of ECMO for neonates is falling, while its use in adults is steady, and the number of centres reporting ECMO outcomes to the Extracorporeal Life Support Registry is increasing.[17] No Australian or New Zealand centres are current active contributors of adult ECMO data to this database. In view of our finding that many centres that provide adult ECMO support do so infrequently, it is unlikely Australian and New Zealand ECMO practices will be recorded in an international database. Until our region has its own database, practice trends will remain unknown. We believe that, in the near future, our region will require a planned approach to the use of ECMO, including:

- establishment of standards of care for centres providing ECMO;
- comprehensive education for staff caring for patients receiving ECMO; and
- a shared regional database to describe the population of patients receiving ECMO.

Conclusions

ECMO experience in small to medium-sized centres is limited, and annual practice rates are low. ECMO is more likely to be implemented in institutions with cardiothoracic or perfusionist services. Indeed, the absence of these services, together with inadequate staff training and skill, were identified as prominent barriers to ECMO practice. Use of ECMO in the context of rescue therapy to facilitate patient transfer to a tertiary centre and outside the setting of an RCT was supported by respondents. There was strong support for an ongoing national database.

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References

1 UK collaborative randomised trial of neonatal extracorporeal membrane oxygenation. UK Collaborative ECMO Trail [sic] Group. *Lancet* 1996; 348: 75-82.
2 Dalton HJ, Rycus PT, Conrad SA. Update on extracorporeal life support 2004. *Semin Perinatol* 2005; 29: 24-33.
3 Zapol WM, Snider MT, Hill JD, et al. Extracorporeal membrane oxygenation in severe acute respiratory failure. A randomized prospective study. *JAMA* 1979; 242: 2193-6.
4 Morris AH, Wallace CJ, Menlove RL, et al. Randomized clinical trial of pressure-controlled inverse ratio ventilation and extracorporeal CO_2 removal for adult respiratory distress syndrome. *Am J Respir Crit Care Med* 1994; 149 (2 Pt 1): 295-305.
5 Felton TW, McCormick BA, Finfer SR, Fisher MM. Life-threatening pulmonary hypertension and right ventricular failure complicating calcium and phosphate replacement in the intensive care unit. *Anaesthesia* 2006; 61: 49-53.

6 Maclaren G, Butt W. Extracorporeal membrane oxygenation and sepsis. *Crit Care Resusc* 2007; 9: 76-80.

7 Oto T, Rosenfeldt F, Rowland M, et al. Extracorporeal membrane oxygenation after lung transplantation: evolving technique improves outcomes. *Ann Thorac Surg* 2004; 78: 1230-5.

8 Auzinger GM, Scheinkestel CD. Successful extracorporeal life support in a case of severe flecainide intoxication. *Crit Care Med* 2001; 29: 887-90.

9 Rosengarten A, Elmore P, Epstein J. Long distance road transport of a patient with Wegener's granulomatosis and respiratory failure using extracorporeal membrane oxygenation. *Emerg Med (Fremantle)* 2002; 14: 181-7.

10 Smith C, Bellomo R, Raman JS, et al. An extracorporeal membrane oxygenation-based approach to cardiogenic shock in an older population. *Ann Thorac Surg* 2001; 71: 1421-7.

11 Maclaren G, Butt W, Cameron P, et al. Treatment of polypharmacy overdose with multimodality extracorporeal life support. *Anaesth Intensive Care* 2005; 33: 120-3.

12 MacLaren G, Pellegrino V, Butt W, et al. Successful use of ECMO in adults with life-threatening infections. *Anaesth Intensive Care* 2004; 32: 707-10.

13 Griffith LE, Cook DJ, Guyatt GH, Charles CA. Comparison of open and closed questionnaire formats in obtaining demographic information from Canadian general internists. *J Clin Epidemiol* 1999; 52: 997-1005.

14 Jones D, Story D, Clavisi O, et al. An introductory guide to survey research in anaesthesia. *Anaesth Intensive Care* 2006; 34: 245-53.

15 Gattinoni L, Pesenti A, Macheroni D, et al. Low-frequency positive-pressure ventilation with extracorporeal CO_2 removal in severe acute respiratory failure. *JAMA* 1986; 256: 881-6.

16 Murray JF, Matthay MA, Luce JM, Flick MR. An expanded definition of the adult respiratory distress syndrome. *Am Rev Respir Dis* 1988; 138: 720-3.

17 Conrad SA, Rycus PT, Dalton H. Extracorporeal Life Support Registry Report 2004. *ASAIO J* 2005; 51: 4-10. ❑

Appendix 1. Questionnaire used in a survey of extracorporeal membrane oxgenation (ECMO)

Australian and New Zealand ECMO Audit

Step 1: SAVE AS ECMO Audit-*hospital name*

Step2: complete survey

Step 3: email to V.Pelligrino@Alfred.org.au

If you are filling out a form for more than hospital please fill out a different form for each hospital

1.01 Hospital name

1.02 Unit director (respondent)

1.03 Type of hospital Public ☐ Private ☐

Types of ICU

2.01 Number of ventilated (EFT) beds *(usual maximum)*

2.02 Number of full time intensivists

2.03 Number of ICU sessions per week covered by VMO's (0-14)

2.04 Perfusionist available YES ☐ NO ☐

2.05 Cardiothoracic service available YES ☐ NO ☐

2.06 Transplant service Heart ☐ Lung ☐ Liver ☐

Attitude to ECMO practice

How many patients have you ever managed that were supported with ECMO

3.01 ADULT

0-2	3-9	10-20	>20

3.02 PAEDIATRIC/NEONATAL

0-2	3-9	10-20	>20

3.03 Do you feel that ECMO should only be applied as part of a multicentre randomized controlled trial for specific conditions

YES ☐

NO ☐

Do you feel that ECMO is an acceptable form of rescue support for patients with potentially reversible forms of cardiac and/or respiratory failure not supportable with conventional modes of ICU support (inotropes, vasopressors, IABP, mechanical ventilation, NO)

3.04 (a) In your unit YES ☐

NO ☐

If you have answered NO in 3.04 (a)

What are the reasons for NOT using ECMO (indicate ALL those applicable)

3.05	COST	
3.06	HIGH MORTALITY	
3.07	LACK OF EVIDENCE TO SUPPORT USE	
3.08	UNAVAILABILITY OF PERFUSION SERVICE	
3.09	UNAVAILABILITY OF CARDIOTHORACIC SERVICE	
3.10	INSUFFICIENT MEDICAL ECMO TRAINING	
3.11	INSUFFICIENT NURSING ECMO TRAINING	
3.12	OTHER	

3.13 (b) In a specialty centre YES ☐

NO ☐

If you have answered NO in 3.13

What are the reasons for NOT using ECMO (indicate ALL those applicable)

3.05	COST	
3.06	HIGH MORTALITY	
3.07	LACK OF EVIDENCE TO SUPPORT USE	
3.08	UNAVAILABILITY OF PERFUSION SERVICE	
3.09	UNAVAILABILITY OF CARDIOTHORACIC SERVICE	
3.10	INSUFFICIENT MEDICAL ECMO TRAINING	
3.11	INSUFFICIENT NURSING ECMO TRAINING	
3.12	OTHER	

ECMO use in your unit

4.01 Has your unit ever used ECMO? YES ☐

NO ☐

How many patients have had ECMO in your (current) unit in the last

4.02 (a) 12 months

0	1-3	4-8	>8

4.03 (b) 3 years

0	1-3	4-8	>8

4.04 If you would offer ECMO in the future in your unit, or, to transport a patient from your unit, would you support de-identified data collection from your ECMO patients being included in an Australian and New Zealand database prospectively?

YES ☐

NO ☐