Venoarterial extracorporeal membrane oxygenation in adults in Aotearoa New Zealand: a single-centre observational study over seven years

Cliodhna P Minogue, Philippa Neal, David A Sidebotham

ABSTRACT

AIM: The aim of this article was to describe the use of venoarterial (VA) extracorporeal membrane oxygenation (ECMO) in adults in Aotearoa New Zealand. Survival at 1 year was the primary outcome. Equity of access was a secondary outcome.

METHODS: We carried out a retrospective cohort study of all patients undergoing VA ECMO between September 2017 and June 2024 in the Cardiothoracic and Vascular Intensive Care Unit (CVICU) at Auckland City Hospital. The CVICU is the national referral centre for adult VA ECMO in New Zealand.

RESULTS: There were 151 patients who received VA ECMO, including 94 (62%) following cardiac surgery and 44 (29%) for cardiogenic shock. Survival to ECMO decannulation, hospital discharge and at 1 year was 114 (76%), 86 (57%) and 80 (53%), respectively. Increased age, non-transplant cardiac surgery and extracorporeal cardiopulmonary resuscitation were associated with decreased survival at 1 year. Major complications occurred in 33/151 (22%) patients and included bleeding in 15/33 (45%) and lower-limb ischaemia in 10/33 (30%). Māori received ECMO at a rate comparable to their population. Of the 144 New Zealand domiciled cases, 13 (9%) were from the South Island.

CONCLUSIONS: These outcomes are comparable to international case series. Reduced access by geographic location underscores the need to further develop regional ECMO sub-centres.

Venoarterial (VA) extracorporeal membrane oxygenation (ECMO) is increasingly used for temporary circulatory support in patients with severe cardiac or cardiopulmonary failure that is refractory to conventional therapy.[1] VA ECMO can be used as a bridge to recovery, to durable mechanical circulatory support or to cardiac transplantation.[2] The main indications for VA ECMO are cardiogenic shock following cardiac surgery, cardiogenic shock associated with ischaemic heart disease, decompensated chronic heart failure and other causes of circulatory collapse, such as massive pulmonary embolism or cardiotoxic drug poisoning. Despite technological advances and increasing clinical experience, VA ECMO is associated with significant morbidity, high resource use and variable outcomes.[3,4]

Overall survival at 1 year following VA ECMO is between 20 and 40%.[5,6] However, survival varies by indication, being highest for fulminant myocarditis (65%)[7–9] and lowest for extracorporeal cardiopulmonary resuscitation (ECPR) (15–30%).[10,11] A large registry-based cohort study across Australia and Aotearoa New Zealand by Serpa Neto et al. reported that approximately 30% of adult VA ECMO recipients were alive and without significant disability at 1 year, with outcome strongly influenced by indication for ECMO; however, the analysis excluded patients receiving ECPR.[6]

Auckland City Hospital, Health New Zealand – Te Whatu Ora Te Toka Tumai, is the national referral centre for adult ECMO in New Zealand. All adult patients receiving ECMO are treated in the Cardiothoracic and Vascular Intensive Care Unit (CVICU), which is a 26-bed, tertiary-level intensive care unit (ICU). The CVICU provides a national retrieval service for adult ECMO. In 2021, we reported our experience of using venovenous (VV) ECMO for treating patients with severe pneumonia.[12]

In the CVICU, the primary criteria used when considering the suitability of a patient for VA ECMO is whether the cardiogenic shock is potentially reversible and, if not, whether the patient is a suitable candidate for durable mechanical circulatory support as a bridge to cardiac transplantation. Age over 60–65 years is a contraindication. Deci-

sion making is by consensus among the CVICU intensivists in consultation with the relevant stakeholders (cardiac surgeons, cardiologists and referring physicians).

This study is a retrospective observational study of the indications and outcomes from VA ECMO in New Zealand. The key research questions were to benchmark the use and outcomes of VA ECMO against the international experience and to evaluate equity of access to VA ECMO on the basis of geography and ethnicity.

Methods

The study was a single-centre retrospective cohort study in patients receiving VA ECMO in the CVICU between 19 September 2017 and 29 June 2024. Reliable data were not recorded before 2017.

Ethics oversight

Following guidance from the National Ethical Standards for Health and Disability Research and Quality Improvement (New Zealand),[13] ethics committee review was not required for this study. As per local policy, the project was approved by the Service Clinical Director, CVICU (14 November 2024).

Research question

Our primary outcome was survival to 1 year following VA ECMO. Secondary outcomes were survival to ECMO decannulation, survival to hospital discharge, the occurrence of complications, equity of access to VA ECMO in terms of place of domicile and ethnicity and whether short- or long-term VA ECMO support was associated with outcome.

Inclusion and exclusion criteria

All patients treated with VA ECMO in the CVICU between 19 September 2017 and June 29 2024 were included. Patients transferred from other hospitals on VA ECMO and patients who subsequently received other forms of ECMO or additional forms of mechanical cardiovascular support were included. The CVICU typically admits adult patients (≥16 years); however, in some circumstances patients younger than 16 years are admitted. No patient who received VA ECMO in the CVICU was excluded.

Data collection

Demographic data were obtained from our institutional ECMO registry. ECMO-specific variables (cannulation strategy, duration of support) and in-hospital outcomes (survival to decannulation, ICU duration of stay, complications and survival to discharge) were obtained from the electronic patient record. Data on 1-year survival were obtained from the New Zealand national registry of Births, Deaths and Marriages. All data were de-identified before analysis.

We collected information on age, sex, ethnicity, district of domicile, indication for VA ECMO, duration of VA ECMO support, cannulation strategy, transition to different ECMO configurations, location of initiation of VA ECMO, major complications, survival to VA ECMO decannulation, CVICU duration of stay, post-CVICU disposition, survival to discharge from our hospital and survival at 1 year. Data were collected by CM between February 2025 and April 2025.

Definitions

Ethnicity was categorised as the single primary ethnic group associated with the patient's national health identifier.

Indications for ECMO were categorised as: 1) cardiogenic shock following cardiac surgery; 2) cardiogenic shock not associated with cardiac surgery; and 3) other. Group 1 comprised any patient receiving VA ECMO within 7 days of cardiac surgery (including lung transplant surgery). Group 1 was subcategorised as non-transplant cardiac surgery, cardiac transplant surgery or lung transplant surgery. Group 2 comprised any non-cardiac surgery patient who received VA ECMO for cardiogenic shock. Group 2 was subcategorised as fulminant myocarditis, decompensated chronic heart failure, acute ischaemic cardiogenic shock, pulmonary embolus or cardiotoxic drug poisoning. Group 3 comprised all other indications for VA ECMO. ECPR was defined as initiation of VA ECMO during the sustained chest compression for circulatory collapse.

Major complications were categorised as: patient haematological (bleeding, thrombosis), limb ischaemia, neurological, or circuit related. Circuit-related complications were defined as complications relating to cannulation, cannula position or the extracorporeal circuit (gas embolism, circuit failure or rupture, haemolysis).

Data analysis

Continuous variables were summarised as median (interquartile range [IQR]). Categorical variables were summarised as proportions (%). All percentages were rounded to integer values.

Potential predictors of 1-year survival following VA ECMO were chosen on clinical grounds and comprised indication for VA ECMO, age, sex, ethnicity, duration of VA ECMO support, and ECPR. The relationship between predictor variables and 1-year survival was tested using univariate logistic regression, without correction for multiple testing. A Chi-squared test was used to evaluate the relationship between 1-year survival and short (≤median) versus long ECMO (>median) duration of ECMO support. In all cases, $p \leq 0.05$ or a 95% confidence interval (CI) around the estimated odds ratio (OR) that excluded one was used to define statistical significance. Data were tabulated in Microsoft Excel (Microsoft Corporation, Redmond, Washington, United States of America) and analysed in R (v4.2.2, R Foundation for Statistical Computing, Vienna, Austria).

Results

There were 152 episodes of VA ECMO in 151 patients. The median (IQR) age was 47 (31–54) and 57 (38%) were female. Figure 1 shows the number of cases per year.

Among the cohort, 142/151 (95%) patients were primarily domiciled in New Zealand. Of the remainder, seven (5%) were primarily domiciled in a Pacific country and two (1%) were visitors from other countries. Tables 1 and 2 show the ethnicity and geographic data for the 142 New Zealand–domiciled patients. Table 3 shows the indications for VA ECMO for the entire cohort. ECPR was performed in 28/151 (19%) patients.

The median (IQR) duration of VA ECMO support was 6 (4–8) days. The median (IQR) CVICU duration of stay was 15 (8–25) days. Of the 151 patients, 114 (76%) survived to ECMO decannulation, 86 (57%) survived to hospital discharge and 80 (53%) were alive at 1 year. Table 4 shows survival at 1 year by age, sex, ethnicity and indication. For patients receiving ECPR, survival at 1 year was 9/28 (32%). For patients receiving VA ECMO for 6 days or less, survival at 1 year was 34/63 (54%); for patients receiving VA ECMO for longer than 6 days, survival at 1 year was 46/88 (52%) (p=0.76).

Increased age and ECPR were significant predictors of death within 1 year (Table 5). Among

Figure 1: Number of cases of venoarterial (VA) extracorporeal membrane oxygenation (ECMO) per year. Only full calendar years are shown. Between 19 September 2017 and 31 December 2017 there were six cases. Between 1 January 2024 and 29 June 2024 there were 15 cases.

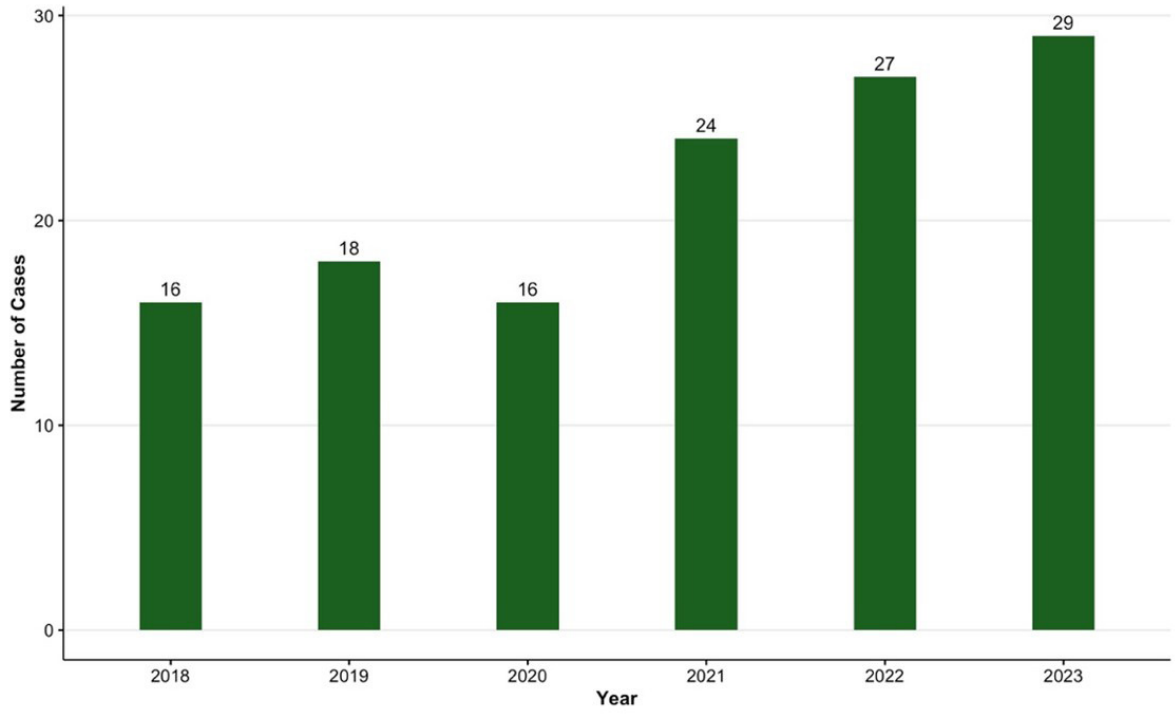

Table 1: Ethnicity. Column one shows the primary ethnicity for the cohort of New Zealand–domiciled patients. Column two shows the ethnic distribution of the New Zealand population from the 2023 Census.[14] Note the total percentage for column two is 115%, which reflects the fact that people can list more than one ethnic affiliation on the census form. Percentages are rounded to integer values.

	N=142 (%)	Proportion of New Zealand population (%)
European	64 (45)	68
Māori	31 (22)	18
Pacific peoples	22 (15)	9
Asian	19 (13)	17
MELAA	4 (3)	2
Other	2 (1)	1

MELAA = Middle Eastern, Latin American, African.

Table 2: Geographic location. Column one shows the geographic location for the cohort of New Zealand–domiciled patients. Column two shows the geographic distribution of New Zealand–domiciled people from the 2023 Census.[14] Percentages are rounded to integer values.

	N=142 (%)	Proportion of New Zealand population (%)
Northern	**92 (65)**	**39**
Greater Auckland	85 (60)	35
Northland	7 (5)	4
Midland (Te Manawa Taki)	**23 (16)**	**20**
Waikato	15 (11)	9
Bay of Plenty	5 (4)	5
Tairāwhiti	1 (1)	1
Rotorua and Taupō	1 (1)	2
Taranaki	1 (1)	3
Central (Te Ikaroa)	**14 (10)**	**18**
Wellington, Kāpiti and Hutt Valley	8 (6)	9
Hawke's Bay	3 (2)	3
Manawatū, Horowhenua and Tararua	1 (1)	4
Whanganui	2 (1)	1
Wairarapa	0	1
South Island (Te Waipounamu)	**13 (9)**	**24**
Canterbury	6 (4)	12
South Canterbury	0	1
Nelson Marlborough	3 (2)	3
West Coast	0	1
Otago and Southland	4 (3)	7

Table 3: Indications for venoarterial (VA) extracorporeal membrane oxygenation (ECMO). Percentages are rounded to integer values.

Indication	N=151 (%)
Cardiac surgery	**94 (62)**
Non-transplant cardiac surgery	54 (36)
Cardiac transplant	25 (17)
Lung transplant	15 (10)
Cardiogenic shock and decompensated heart failure	**46 (30)**
Fulminant myocarditis	11 (7)
Decompensated chronic heart failure	12 (8)
Acute ischaemic cardiogenic shock	13 (9)
Pulmonary embolus	8 (5)
Cardiotoxic drugs	2 (1)
Other	**11 (7)**
Septic shock	3 (2)
Drowning	2 (1)
Pulmonary haemorrhage	2 (1)
Hypoxic cardiac arrest	2 (1)
Hypertensive crisis	1 (1)
Amniotic fluid embolism	1 (1)

cardiac surgery patients, heart and lung transplant surgery were associated with a reduced risk of death within 1 year (Table 5).

For patients who survived to CVICU discharge, 18/88 (20%) were discharged to another ICU, with the remaining 70/88 (80%) transferred to a ward within Auckland City Hospital.

Thirty-four major complications occurred in 33/151 (22%) patients comprising haematological (16/33, 49%), lower limb ischaemia (10/33, 30%) and circuit related (8/33, 24%). Patient haematological complications comprised bleeding, with one case of thrombus. Of the eight circuit-related complications, two were due to cannula malposition, four involved vessel injury during cannulation, one involved circuit-related haemolysis and there was one case of catastrophic air embolism.

There were 17/151 (11%) patients who had more than one cannula configuration during their period of VA ECMO support. For the initial ECMO configuration, the aortic root was used for arterial return in 75/151 (50%) patients, with the remainder having cannulation of a femoral artery. A distal perfusion cannula was used in all cases of femoral arterial cannulation.

Discussion

This single-centre observational cohort study provides insights into the use of VA ECMO in adults in New Zealand. There was a trend towards increasing use of VA ECMO over time (Figure 1). Overall survival at 1 year was 53%, which compares favourably to the Australasian and international experience.[5,6,14,15] The 2025 study by Serpa Neto et al. reported the outcomes from VA ECMO among 389 patients in 26 centres across Australia and New Zealand for the years 2019–2023 and found that overall survival at 1 year was 44%.[6] However, Serpa Neto et al. did not report individual centre and country data and their analysis excluded patients undergoing ECPR.[6]

Table 4: Survival at 1 year by age, sex, ethnicity and indication. Percentages are rounded to integer values.

		N	Alive at 12 months (%)
All patients		151	80 (53)
Age			
	≤16	4	3 (75)
	17–29	27	19 (70)
	30–49	53	27 (51)
	50–65	56	28 (50)
	≥65	11	3 (27)
Sex			
	Male	94	50 (53)
	Female	57	30 (53)
Ethnicity			
	European	64	37 (58)
	Māori	31	19 (61)
	Pacific peoples	30	12 (40)
	Asian	20	9 (45)
	MELAA	4	1 (25)
	Other	2	1 (50)
Indication			
Cardiac surgery		94	50 (53)
	Non-transplant	54	20 (40)
	Cardiac transplant	25	18 (72)
	Lung transplant	15	12 (80)
Non-cardiac surgery		46	23 (50)
	Fulminant myocarditis	11	4 (36)
	Decompensated heart failure	12	9 (75)
	Acute ischaemia	13	5 (38)
	Pulmonary embolus	8	5 (62)
	Cardiotoxic drugs	2	0 (0)
Other		11	7 (64)

MELAA = Middle Eastern, Latin American, African.

Table 5: Predictors of mortality within 1 year. An odds ratio (OR) >1 indicates increased mortality within 1 year.

Variable	OR (95% CI)	p-value
Age (years)	1.03 (1.01–1.05)	0.01
Duration of VA ECMO (days)	1.07 (0.99–1.17)	0.08
Sex (male relative to female)	0.97 (0.51–1.90)	0.95
Ethnicity (relative to European)		
Māori	0.87 (0.35–2.07)	0.75
Pacific peoples	2.06 (0.86–5.07)	0.11
Asian	1.67 (0.61–4.70)	0.32
ECPR (relative to no ECPR)	2.88 (1.24–7.17)	0.02
Indication:		
Non-cardiac surgery (relative to cardiac surgery)	1.14 (0.56–2.31)	0.72
Indication: cardiac surgery		
Heart transplant (relative to non-transplant cardiac surgery)	0.23 (0.08–0.62)	0.005
Lung transplant (relative to non-transplant cardiac surgery)	0.15 (0.03–0.53)	0.006

ECPR = extracorporeal resuscitation; CI = confidence interval; VA ECMO = venoarterial extracorporeal membrane oxygenation.

An interesting feature of the data is that 43% of the patients who died within the first year, died following successful ECMO decannulation, mostly while in hospital. Of those who survived to hospital discharge, 93% were alive at 1 year. Serpa Neto et al. did not distinguish between in-hospital deaths that occurred during or following ECMO decannulation.[6]

While the New Zealand outcomes presented here are encouraging, it is impossible to determine the extent to which survival was influenced by the quality of VA ECMO management or the selection criteria that was used for offering the intervention. The cohort presented here included proportionally more cardiothoracic surgical patients (62% versus 28%) and fewer cardiogenic shock patients (30% versus 41%) than the Australasian-wide data reported by Serpa Neto et al.[6] Additionally, the cohort presented here were younger (median [IQR] 47 [31–54] versus 57 [44–65] years) than that reported by Serpa Neto et al.[6]

The high proportion of cardiothoracic surgical patients in the cohort presented here reflects the high use of VA ECMO following heart and lung transplantation, which was associated with a high survival (Table 4). We apply a relatively restrictive approach to providing VA ECMO for patients with cardiogenic shock and for providing ECPR. ECPR, in particular, is associated with poor survival.[9–11] Thus, differences in selection criteria may explain the difference in survival in this cohort compared to the data reported by Serpa Neto et al.[6]

Survival at 1 year was similar across the two main indication groups (Table 4). Increased age and ECPR were significantly associated with increased mortality within 1 year and transplant cardiac surgery (heart and lung) with reduced mortality within 1 year (Table 5), which is concordant with international experience.[6,7,9] In the cohort presented here, 1-year survival in the cardiac surgery group was 53% (which was coincidentally the same as the overall survival) and was higher than that reported in other studies.[6,16] In particular, Serpa Neto et al. reported a 1-year survival of 41% among surgical patients.[6] In the Postcardiotomy Extracorporeal Life Support (PELS-1) study, which

was a large international cohort study involving over 2,000 patients who received VA ECMO following cardiac surgery, survival to hospital discharge was 39%.[16] The relatively high survival among cardiac surgical patients in the cohort reported here likely reflects the high proportion undergoing heart or lung transplantation (43%, Table 3).

Other features of the survival data warrant discussion. Survival at 1 year for the 11 patients with fulminant myocarditis was only 36%, which is lower than that reported in other series.[7–9] Given the small number of patients (11/151) with fulminant myocarditis, it is difficult to draw meaningful conclusions. Survival among the 29/151 patients who received ECPR was only 31%, which is concordant with other series.[10,11] The fact that duration of ECMO was not associated with survival suggests that longer ECMO runs were not indicative of treatment futility. Median duration of ECMO was shorter in our VA ECMO cohort (6 days) compared with our previously reported VV ECMO cohort (10 days).[12]

The rate of major complications was high (22%), but lower than that reported in other series, including the Australasian-wide data reported by Serpa Neto et al.[6,17] The high rate of complications reflects the invasive nature of the technique and the critical state of most patients who receive VA ECMO. Data were not collected on renal failure, but in other series more than two-thirds of patients supported by VA ECMO required renal replacement therapy.[6,18]

Given that people in New Zealand are geographically dispersed, ethnically diverse and that Auckland City Hospital is the sole referral centre, equity of access to VA ECMO was an important research question. Māori and Pacific patients were fairly evenly represented relative to their proportions in the general population (Table 1).[19] However, compared with non-Māori, Māori have higher rates of coronary artery and rheumatic disease.[20] Furthermore, Māori who undergo cardiac surgery have a higher risk category score and experience higher mortality than non-Māori.[21] Consequently, Māori may be expected to have a higher requirement for VA ECMO than non-Māori. We identified a similar issue in our study of VV ECMO: while the proportion of VV ECMO patients who were Māori was similar to their proportion in the population,[12] the rate of pneumonia for Māori is roughly three times the rate for non-Māori and Māori tend to experience more severe disease.[22]

Delivery of VA ECMO was not distributed equitably by geographic location, with the greater Auckland Region being over-represented and the South Island being under-represented (Table 2). In the cohort, 60% of patients came from the greater Auckland Region, with this area accounting for 35% of the New Zealand population. By contrast, only 9% came from the South Island, with this area accounting for 24% of the population. Our findings are concordant with a recent Australasian study, which found that among propensity matched controls, ECMO was less likely to be provided to patients presenting to regional hospitals or to those living in remote locations.[23] The lack of availability of ECMO in the South Island has recently been highlighted.[24] In New Zealand, with a single national referral centre, there are limited opportunities for providing emergency VA ECMO outside of Auckland City Hospital.[25] Key problems include the ready availability of equipment and expertise while maintaining consistent governance over patient selection.[25] High-volume ECMO centres have better long-term outcomes, lower mortality rates and lower rates of complications than low-volume centres.[26,27] While there is no universally accepted standard, in one study a case load of more than 30 per year was associated with improved outcomes.[27] The CVICU cares for an average of 50–60 ECMO cases per year (VV and VA ECMO).

During the study period, we retrieved 17 patients on VA ECMO from six different centres. The majority (15/17) were retrieved from North Island centres, and all were from centres with cardiac surgical units. To address the issue of geographic inequity, we are developing a model where, in appropriate patients, ECMO is initiated by the referring team and the patient subsequently retrieved to the CVICU. At the time of writing, patients in Waikato, Wellington and Dunedin hospitals have been initiated on VA ECMO and retrieved to the CVICU. Traditionally, all patients transferred to the CVICU were placed on ECMO by the retrieval team.

Our study has several weaknesses. The data are retrospective and from a single ECMO centre; however, the study does report the New Zealand national experience. We did not collect data on functional outcomes and so cannot comment on long-term disability among survivors. The small numbers among sub-groups (e.g., patients with fulminant myocarditis) means it is hard to draw firm conclusions on the outcomes for some specific indications. However, as a single national referral centre, our data offer a unique insight into the provision of VA ECMO in New Zealand and provide

confidence that our overall outcomes and rates of complications are broadly comparable with the international experience.

Conclusions

The findings demonstrate that the outcomes from VA ECMO in New Zealand compare favourably to both the Australasian and wider international experience. The geographic distribution of patients receiving VA ECMO does not match the population distribution of New Zealand. One way to address this issue is to further develop regional centres capable of initiating VA ECMO.

COMPETING INTERESTS
The authors declare they have no competing interests.

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Te Tiriti and equity statement: This study was done in accordance with the principles of Te Tiriti o Waitangi, recognising Māori as tangata whenua and partners in health research. The analysis sought to identify and report inequities in access to venoarterial extracorporeal membrane oxygenation (VA ECMO) for Māori and Pacific peoples, with the aim of informing equitable critical care service delivery and supporting systemic improvement in advanced life-support accessibility across Aotearoa New Zealand.

AUTHOR INFORMATION
Cliodhna P Minogue: Registrar, Cardiothoracic and Vascular Intensive Care Unit, Auckland City Hospital, Health New Zealand – Te Whatu Ora Te Toka Tumai Auckland, Auckland, Aotearoa New Zealand.
Philippa Neal: ECMO Nurse Specialist, Cardiothoracic and Vascular Intensive Care Unit, Auckland City Hospital, Health New Zealand – Te Whatu Ora Te Toka Tumai Auckland, Auckland, Aotearoa New Zealand.
David A Sidebotham: Intensivist, Cardiothoracic and Vascular Intensive Care Unit, Auckland City Hospital, Health New Zealand – Te Whatu Ora Te Toka Tumai Auckland, Auckland, Aotearoa New Zealand.

CORRESPONDING AUTHOR
David A Sidebotham. Intensivist, Cardiothoracic and Vascular Intensive Care Unit, Auckland City Hospital, Health New Zealand – Te Whatu Ora Te Toka Tumai Auckland, 2 Park Road, Auckland, Aotearoa New Zealand. E: dsidebotham@adhb.govt.nz

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