EXCEL 2023 Annual Report

Prepared by:

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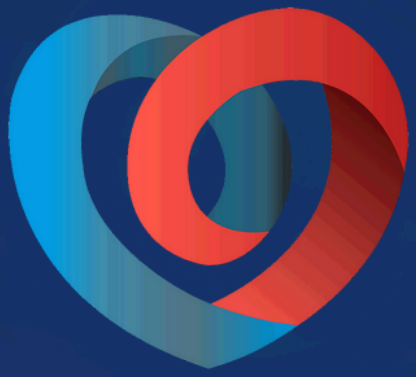

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EXECUTIVE SUMMARY

Introduction

The EXCEL Registry aims to create a binational, multidisciplinary network of integrated care for patients suffering acute cardiac or respiratory failure requiring extracorporeal membrane oxygenation (ECMO). The overarching goal is to monitor long-term outcomes and identify best practices for ECMO treatment. This report provides critical feedback to Australian and New Zealand ECMO sites regarding patient outcomes, offering a comprehensive analysis of data from both local and binational perspectives.

Data Collection and Scope

The EXCEL Registry includes all patients who underwent ECMO during their hospitalisation. This encompasses a broad range of data, including demographic, admission, ECMO, and hospital discharge details, representing patients admitted to the participating ICUs within the reporting period. Furthermore, the report includes patients retrieved to and from these sites. Kaplan-Meier survival curves and follow-up data represent all EXCEL patients at each site entered into the database. It is important to note that all data presented in this report has been meticulously collected by the Investigators and Research Coordinators at each participating site. Data are available for download by EXCEL participants sites via the EXCEL REDCap database. The information is provided confidentially to the EXCEL Registry and should be shared only with relevant hospital staff, including members of the hospital executive committee. Reproduction of the report is prohibited without prior permission from the EXCEL Management Committee.

Reporting Period and Data Considerations

Data completion reflects the data entered for the reporting period 01 January 2023 to 31 December 2023. Data was extracted on 24 June 2025 and a few updates made on 2 September 2025 any data entered after this date is not represented in this report.

Year in Review: ECMO Research and Funding Milestones

The ECMO program saw significant progress over 2023, marked by new and continued funding, key project milestones being met and numerous high-impact publications. Two trials were awarded NHMRC/MRFF funding including the RECOMMEND Platform trial and National Research Data Infrastructure Trial.

A pilot study focusing on ECMO survivors, known as the ECMO-Prompt, was awarded a grant from the Australia and New Zealand Intensive Care Foundation and will be launched in 2024. A trial embedded in the Registry that measured oxygen targets on VA-ECMO (BLENDER) completed recruitment and a number of noteworthy publications are starting to emerge from the ECMO program in 2023.

Several noteworthy publications emerged from the ECMO program in 2023, including:

- A review of ECMO in adults published in *Cochrane Systematic Reviews*
- A review of ECPR for refractory cardiac arrest in Australia published in *Medical Journal of Australia*
- Research on machine learning for risk prediction in VA-ECMO (ECMO-PAL) published in *Intensive Care Medicine*
- A study of VA-ECMO return cannula and hemolysis published in *ASAIO*

Additionally, a clinician survey of research priorities for ECMO and ECPR (AuCC), A qualitative sub-study on challenges for ECMO implementation in nursing cohorts (AuCC), and the protocol for a study on oxygen targets in VA-ECMO (BLENDER) (CCR) were accepted.

Growth of the EXCEL Registry

The EXCEL Registry continues to grow, now including seven embedded studies and reaching over **1,800 patients** enrolled.

The second annual EXCEL Symposium, held in April 2023, featured the introduction of new embedded studies and fostered meaningful discussions on a wide range of relevant topics. Dr Eddy Fan (Toronto General Hospital), the keynote speaker, presented on two important topics: International registries and platform trials in ECMO, and Current practice on ECCO2R.

Ongoing Research

We are pleased to recognize the ongoing contributions of the postgraduate researchers within the ECMO program, whose work continues to shape the future of ECMO-related research, including Paul Ross and Gemma Pound. We have several new students commencing in the next 12 months.

Acknowledgements

The progress outlined in this report would not be possible without the dedication and hard work of the Investigators, Research Coordinators, and staff at the participating ECMO sites. We would also like to extend our thanks to Dr. Andrew Stephens and the Australian and New Zealand Intensive Care Research Centre for their ongoing support. For more information about the EXCEL Registry, please visit the website: https://www.monash.edu/medicine/sphpm/excel.

Conclusion

The year 2023 was a significant and impactful one for the EXCEL Registry and the ECMO program, laying the groundwork for an even more transformative 2024. We remain committed to advancing research, improving patient care, and fostering collaboration across our binational network. As always, we are deeply grateful for the continued engagement and dedication of everyone involved. On behalf of the EXCEL Management Committee, thank you for your ongoing support and your commitment to excellence in ECMO care and research.

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The Dicker Family

EXCEL Registry Management Committee

Carol Hodgson (Chair), Ben Fulcher, Shannah Anderson, Steve Bernard, Daniel Brodie, Heidi Buhr, Aidan Burrell, Jamie Cooper, Craig Dicker, Eddy Fan, John Fraser, David Gattas, Lisa Higgins, Ingrid Hopper, Sue Huckson, Annie Jones, Jasmin Board, Natalie Linke, Ed Litton, Shay McGuiness, Priya Nair, Neil Orford, Rachael Parke, Vin Pellegrino, David Pilcher, Benjamin Reddi, Ary Serpa Neto, Dion Stub, Tony Trapani, Andrew Udy,

We would like to thank the participating ECMO centres and patients for their time and generous contribution to this work. The EXCEL Registry is coordinated by the Australian and New Zealand Intensive Care Research Centre (ANZIC-RC) in the School of Public Health and Preventive Medicine, Monash University.

Consumer Engagement

Patient engagement remains important to the EXCEL Registry, ensuring that research priorities and protocols reflect the lived experiences and needs of the ECMO community.

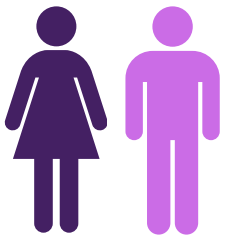
ECMO patients Shannah and Craig continued to contribute invaluable insights as active members of the EXCEL Management Committee.

A standout moment of the year was Sherene's moving presentation at the 2023 EXCEL Symposium, where she shared her personal ECMO experience. Her heartfelt song dedicated to clinicians, researchers, and fellow patients resonated powerfully with the audience - leaving not a dry eye in the room. Watch Sherene's presentation: https://www.youtube.com/watch?v=ourWzuQPOFo

2023 Year in Review - A snapshot

1835

Total ECMO patients admitted to Australian hospitals between 2019 and 2023



65%

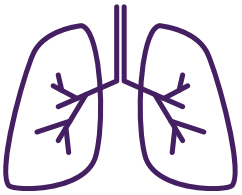
Were male ECMO patients **overall** (2019-2023)

49.5

Mean age (years) of ECMO patients **overall** (2019-2023)

43%

Patients received ECMO for cardiac support in 2023

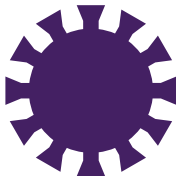


34%

Patients received ECMO for respiratory support in 2023

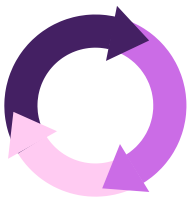
23%

Patients received ECMO CPR in 2023



4%

Patients received ECMO due to COVID-19 in 2023



4.9 days

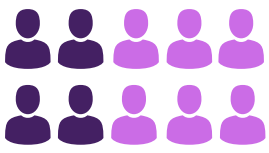
Median ECMO treatment

12.4 days

Median ICU stay

21.4 days

Median hospital stay



55.3%

Patients survived ECMO

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ABBREVIATIONS AND ACRONYMS

Table 1: Abbreviations and Acronyms

AMI	Acute myocardial infarction
ANZICS	Australian and New Zealand Intensive Care Society
ARDS	Acute respiratory distress syndrome
CNS	Central nervous system
COVID-19	Coronavirus disease of 2019
CPR	Cardiopulmonary resuscitation
DVT	Deep vein thromboembolism
ECPR	Extracorporeal cardiopulmonary resuscitation used for advanced resuscitation
ED	Emergency Department
ELSO	Extracorporeal Life Support Organisation
EQ-5D-5L	EuroQol 5-Dimension 5-Level
GI	Gastrointestinal
ICU	Intensive Care Unit
IQR	Interquartile range
LA	Left atrium
LOS	Length of stay
LVD	Left ventricular distention
NHMRC	National Health and Medical Research Council
PA	Pulmonary artery
REDCap	Research Electronic Data Capture
RESP	Respiratory ECMO survival prediction
SD	Standard deviation
TBI	Traumatic brain injury
VA	Venoarterial ECMO
VAD	Ventricular assist device
VF	Ventricular fibrillation
VV	Venovenous ECMO
WHODAS 2.0 12L	World Health Organisation Disability Assessment Schedule 2.0 12 Level

SITE ENROLMENT

The EXCEL Registry continues to engage eligible sites in Australia and New Zealand to contribute data to the registry. An eligible site is defined as a site currently undertaking ECMO as identified by Australian modification of the International statistical classification of diseases and health related problems, 10th revision (ICD-10-AM) coding data provided by the Australian Government Department of Health, or as reported by external sources (internet search, surgeons or site staff).

The list of eligible sites is dynamic and updated regularly based on information obtained from intensive care clinicians and site staff, and information gleaned from internet search engines and websites. The EXCEL Registry maintains a 'watch list' of sites identified as having the potential to undertake occasional ECMO.

A participating site is defined as any site that has been granted EXCEL ethics and governance approval and data collection for the registry has commenced. The total number of participating sites throughout 2023 was 28 of the 30 sites (Figure 1). Transferred patients show up as datapoints at their site of ECMO initiation. This report includes a single entry for each patient who received ECMO in 2023. In case where patients were transferred between hospitals during ECMO treatment, enrolment is attributed solely to the initiating hospital to avoid duplication data.

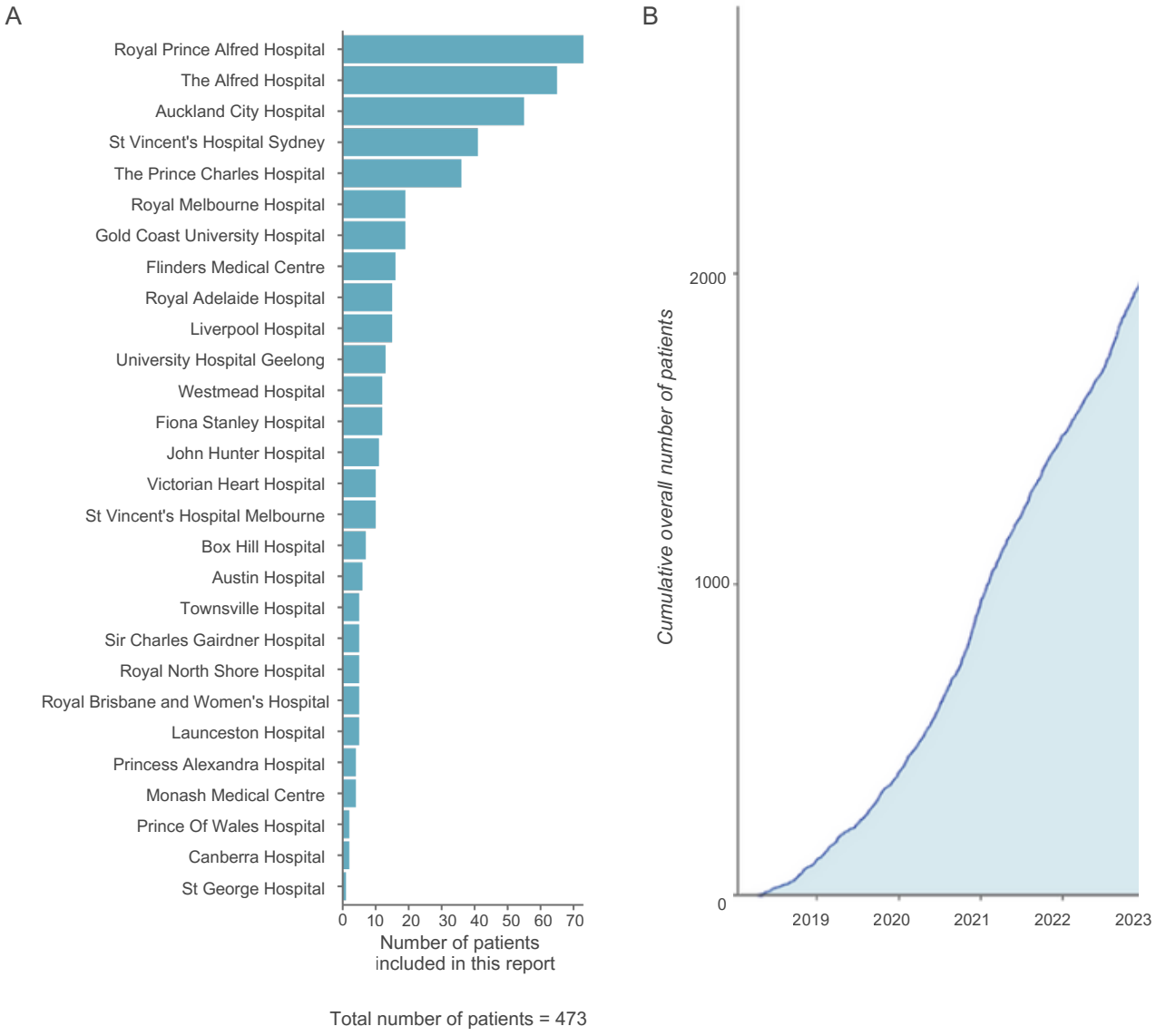

Figure 1: Number of patients included between January 2023 and December 2023 (A), Cumulative overall site enrolment from 2019 to 2023 (B)

DATA COMPLETION

All data entered in this report has been collected by Investigators and Research Coordinators at each of the participating sites. Data is available to download by the Principal Investigator via the EXCEL REDCap database. Data is provided confidentially to the EXCEL Registry.

Over 96% of data was completed for all forms within the registry, with over 97% of data completed for most forms. This work would not have been possible without the ongoing efforts of the many intensive care specialists, nurses, research coordinators and other hospital staff who contribute data to the EXCEL Registry. We would like to thank them for their commitment (Figure 2). We would also like to thank the patients who allow the EXCEL Registry to retain their data.

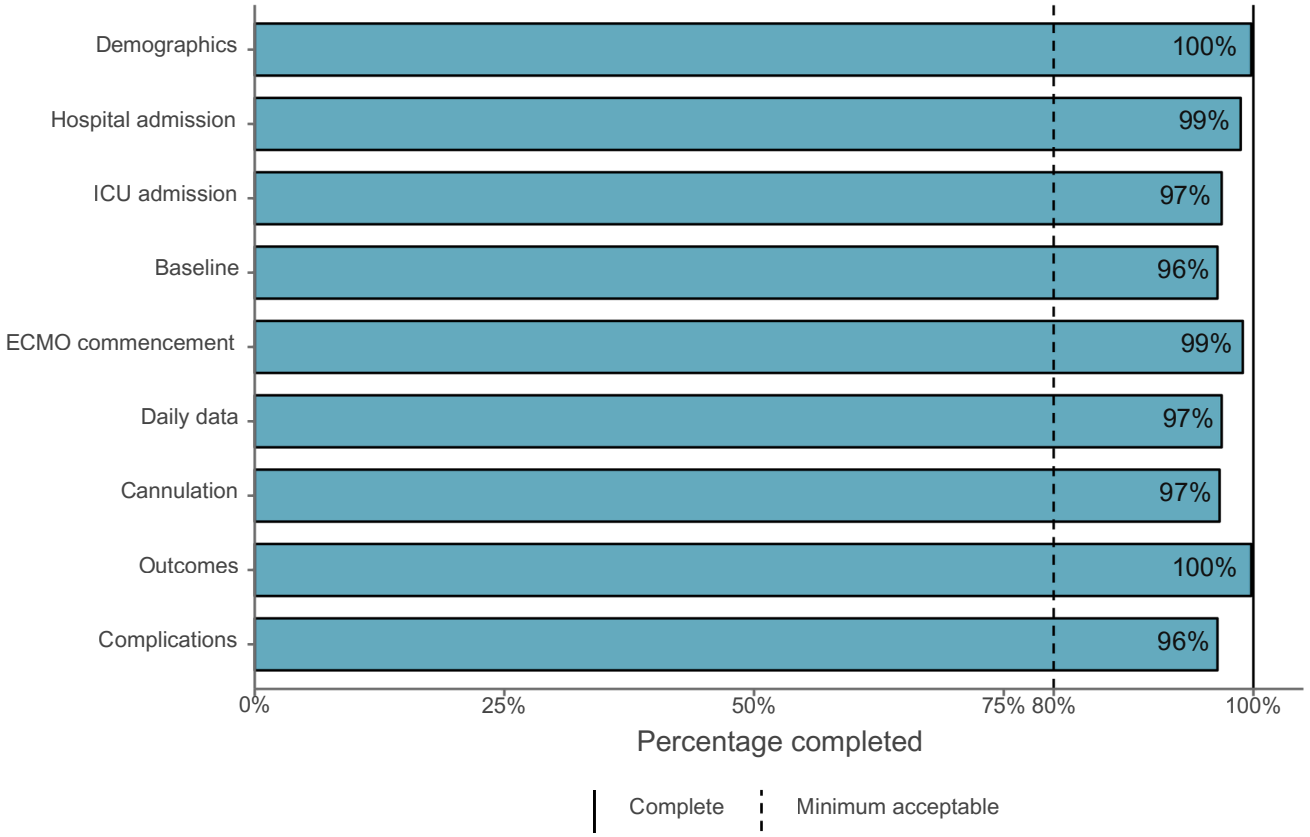

Figure 2: Data completion: EXCEL registry forms

SUMMARY DATA

Table 2 shows summary data across all sites, separated for the type of ECMO (VV-ECMO, VA-ECMO and ECPR). There were 18 (4%) patients who were diagnosed with COVID-19 who received ECMO in this period.

Table 2: Summary information by ECMO mode

	V-V (N=161)	V-A (N=205)	ECPR (N=107)	Total (N=473)
COVID-19 status				
- Confirmed COVID-19 patients	9 (5.6%)	5 (2.5%)	4 (3.7%)	18 (3.8%)
- Other patients	151 (94.4%)	197 (97.5%)	103 (96.3%)	451 (96.2%)
- Total	160	202	107	469
- Missing	1	3	0	4
Age				
- Mean (SD)	43.9 (15.2)	50.7 (16.0)	49.8 (14.5)	48.2 (15.7)
- Median (IQR)	44.0 (33.0, 55.0)	52.0 (39.0, 63.0)	52.0 (41.0, 60.5)	50.0 (37.0, 60.0)
- Range	10.0 - 77.0	12.0 - 86.0	16.0 - 78.0	10.0 - 86.0
- Missing	0	0	0	0
ECMO commencement location				
- Bedside	130 (80.7%)	93 (45.4%)	66 (61.7%)	289 (61.1%)
- Operative theatre	30 (18.6%)	91 (44.4%)	9 (8.4%)	130 (27.5%)
- Cath lab	1 (0.6%)	20 (9.8%)	18 (16.8%)	39 (8.2%)
- At scene	0 (0.0%)	1 (0.5%)	14 (13.1%)	15 (3.2%)
- Total	161	205	107	473
- Missing	0	0	0	0
ECMO outcome				
- Deceased	53 (33.2%)	79 (39.7%)	77 (72.0%)	209 (44.8%)
- Survived	107 (66.8%)	120 (60.3%)	30 (28.0%)	257 (55.2%)
- Total	160	199	107	466
- Missing	1	6	0	7
ECMO duration (days)				
- Mean (SD)	12.2 (16.3)	6.2 (5.5)	3.3 (3.1)	7.6 (10.8)
- Median (IQR)	7.6 (3.4, 13.0)	5.0 (2.9, 7.4)	2.3 (0.8, 4.6)	4.9 (2.3, 8.5)
- Range	0.2 - 144.6	0.0 - 42.0	0.0 - 14.2	0.0 - 144.6
- Missing	2	3	4	9
ICU length of stay (days)				
- Mean (SD)	29.0 (32.9)	17.9 (20.2)	9.0 (11.0)	19.7 (25.1)
- Median (IQR)	20.9 (10.1, 39.1)	12.6 (6.4, 20.9)	5.2 (1.1, 12.4)	12.4 (5.3, 24.8)
- Range	0.0 - 314.9	0.0 - 170.5	0.0 - 52.4	0.0 - 314.9
- Missing	0	1	0	1
Hospital length of stay (days)				
- Mean (SD)	45.1 (46.2)	34.3 (35.7)	14.1 (18.9)	33.0 (38.3)
- Median (IQR)	31.3 (17.0, 58.4)	23.8 (10.9, 45.6)	7.0 (1.6, 20.6)	21.4 (8.3, 45.9)
- Range	0.4 - 337.9	0.7 - 217.3	0.0 - 122.6	0.0 - 337.9
- Missing	19	14	4	37

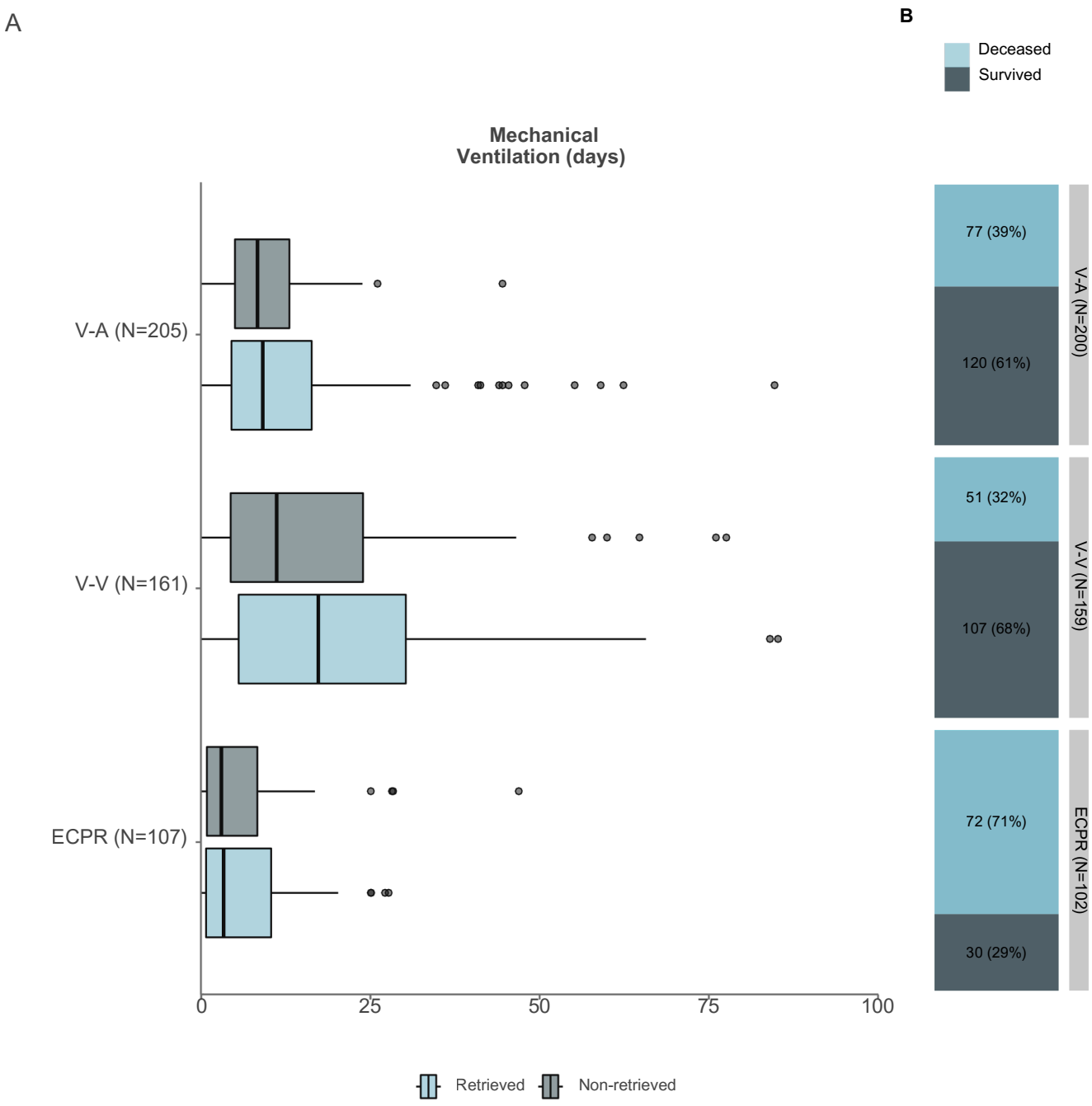

Figure 3: Summary data for mechanical ventilation by ECMO Mode.
Note, ventilation days after 100 days are not presented on this graph.

Pre-ECMO DATA

Data collected immediately prior to ECMO commencement.

Indications

Tables 3, 4 and 5 show the indication for ECMO. For VV-ECMO, VA-ECMO and ECPR respectively, the most common indication was ARDS (63%), AMI (20%) and AMI (43%). VV-ECMO was used post lung transplant (9%) and VA-ECMO was used post heart transplant (5%).

Table 3: ECMO indication (V-V)

	Overall (N=161)
Respiratory indication	
- ARDS (risk factor)	102(63.3%)
- Asthma	7 (4.3%)
- Chronic end stage lung disease	4 (2.5%)
- Direct lung trauma	10 (6.2%)
- Drug/toxin pulmonary disease	0 (0.0%)
- Focal lung disease (not ARDS)	17 (10.6%)
- Management of airway obstruction	2 (1.2%)
- Post lung transplant	16 (9.9%)
- Pulmonary vasculitis/haemorrhage	3 (1.8%)
- Total	161
- Missing	0

Table 4: ECMO indication (V-A)

	Overall (N=205)
Cardiac indication	
- Acute myocardial infarction (AMI)	41 (20.0%)
- Peri-operative support	46 (22.5%)
- Acute decompensated heart failure	38 (18.6%)
- Pulmonary embolism	19 (9.3%)
- Myocarditis	14 (6.8%)
- Advanced pulmonary hypertension	9 (4.4%)
- Post heart transplant	9 (4.4%)
- Chronic cardiomyopathy	9 (4.4%)
- Septic shock	6 (2.9%)
- Toxic	4 (1.9%)
- Chronic graft (heart) dysfunction	4 (1.9%)
- Primary arrhythmia (Channelopathy)	3 (1.4%)
- Congenital heart disease	2 (1.0%)
- Total	204
- Missing	1

Table 5: ECMO indication (ECPR)

	Overall (N=107)
Indication	
- Acute myocardial infarction (AMI)	45 (43.2%)
- Primary arrhythmia (Channelopathy)	20 (19.2%)
- Acute decompensated heart failure	12 (11.5%)
- Pulmonary embolism	10 (9.6%)
- Septic shock	4 (3.8%)
- Myocarditis	3 (2.8%)
- Chronic cardiomyopathy	3 (2.8%)
- Toxic	2 (1.9%)
- ARDS (risk factor)	2 (1.9%)
- Peri-operative support	1 (1.0%)
- Advanced pulmonary hypertension	1 (1.0%)
- Congenital heart disease	1 (1.0%)
- Post heart transplant	0 (0.0%)
- Direct lung trauma	0 (0.0%)
- Post lung transplant	0 (0.0%)
- Management of airway obstruction	0 (0.0%)
- Chronic graft (heart) dysfunction	0 (0.0%)
- Chronic end stage lung disease	0 (0.0%)
- Asthma	0 (0.0%)
- Focal lung disease (not ARDS)	0 (0.0%)
- Pulmonary vasculitis/haemorrhage	0 (0.0%)
- Total	104
- Missing	3

Admission

Table 6: Hospital and ICU admission source

	Overall (N=473)
Hospital admission source	
- Home	235 (49.7%)
- Other acute hospital ICU	147 (31.1%)
- Other acute hospital (not ICU/ED)	53 (11.2%)
- Other hospital ED (like ICU above)	36 (7.6%)
- Rehabilitation	1 (0.2%)
- Mental health	1 (0.2%)
- Total	473
- Missing	0
ICU admission source	
- ICU, other hospital	132 (29.0%)
- Operative theatre/recovery	103 (22.6%)
- ED	95 (20.9%)
- Catheter lab	49 (10.8%)
- Other hospital	36 (7.9%)
- Ward	35 (7.7%)
- ICU, same hospital	4 (0.9%)
- Direct ICU admission (from home)	1 (0.2%)
- Total	455
- Missing	18

ECMO DATA

Length of stay

Table 7 describes the duration of time on ECMO and the length of stay in ICU and in hospital for each type of ECMO (VV ECMO, VA ECMO and ECPR). Patients on V-V ECMO had the longest ECMO run (median 7.6 days) and the longest ICU and hospital stay (median 20.9 and 31.3 respectively).

Table 8 describes the length of stay stratified by transfer status (retrieved versus non-retrieved patients). Patients who were retrieved had a longer duration of ECMO (median 6.3 days versus 4 days) and a longer ICU length of stay (median 15.1 versus 10.7 days).

Table 7: Length of stay (days) stratified by ECMO type

	V-V (N=161)	V-A (N=205)	ECPR (N=107)	Total (N=473)
ECMO duration				
- Median (IQR)	7.6 (3.4, 13.0)	5.0 (2.9, 7.4)	2.3 (0.8, 4.6)	4.9 (2.3, 8.5)
- Total	159	202	103	464
- Missing	2	3	4	9
ICU length of stay (days)				
- Median (IQR)	20.9 (10.1, 39.1)	12.6 (6.4, 20.9)	5.2 (1.1, 12.4)	12.4 (5.3, 24.8)
- Total	161	204	107	472
- Missing	0	1	0	1
Hospital length of stay (days)				
- Median (IQR)	31.3 (17.0, 58.4)	23.8 (10.9, 45.6)	7.0 (1.6, 20.6)	21.4 (8.3, 45.9)
- Total	142	191	103	436
- Missing	19	14	4	37

Table 8: Length of stay (days) stratified by transfer status

Type of ECMO		Retrieved (N=257)	Non-retrieved (N=204)	Total (N=461)
V-V	**ECMO duration**			
	- Median (IQR)	8.8 (5.0, 18.3)	4.5 (3.1, 8.7)	7.6 (3.4, 13.0)
	- Total	96	61	157
	- Missing	2	0	2
	ICU length of stay (days)			
	- Median (IQR)	24.1 (13.0, 43.0)	13.3 (6.6, 30.0)	21.6 (10.5, 39.3)
	- Total	98	61	159
	- Missing	0	0	0
	Hospital length of stay (days)			
	- Median (IQR)	41.1 (19.8, 64.8)	23.0 (12.6, 53.9)	32.2 (16.9, 58.4)
	- Total	81	59	140
	- Missing	17	2	19
V-A	**ECMO duration**			
	- Median (IQR)	5.9 (2.9, 8.5)	4.6 (3.3, 6.4)	5.0 (3.1, 7.5)
	- Total	114	83	197
	- Missing	0	3	3
	ICU length of stay (days)			
	- Median (IQR)	12.7 (7.7, 24.9)	12.2 (6.8, 20.3)	12.7 (7.1, 21.6)
	- Total	113	86	199
	- Missing	1	0	1
	Hospital length of stay (days)			
	- Median (IQR)	29.7 (16.9, 49.4)	20.4 (9.7, 37.2)	25.0 (12.6, 46.4)
	- Total	105	81	186
	- Missing	9	5	14
ECPR	**ECMO duration**			
	- Median (IQR)	3.5 (1.1, 5.8)	2.2 (0.9, 4.0)	2.8 (1.0, 4.9)
	- Total	44	54	98
	- Missing	1	3	4
	ICU length of stay (days)			
	- Median (IQR)	7.1 (1.1, 15.1)	6.1 (1.9, 11.1)	6.1 (1.6, 12.9)
	- Total	45	57	102
	- Missing	0	0	0
	Hospital length of stay (days)			
	- Median (IQR)	8.4 (1.2, 21.9)	7.0 (2.1, 20.0)	7.1 (1.8, 20.8)
	- Total	43	55	98
	- Missing	2	2	4

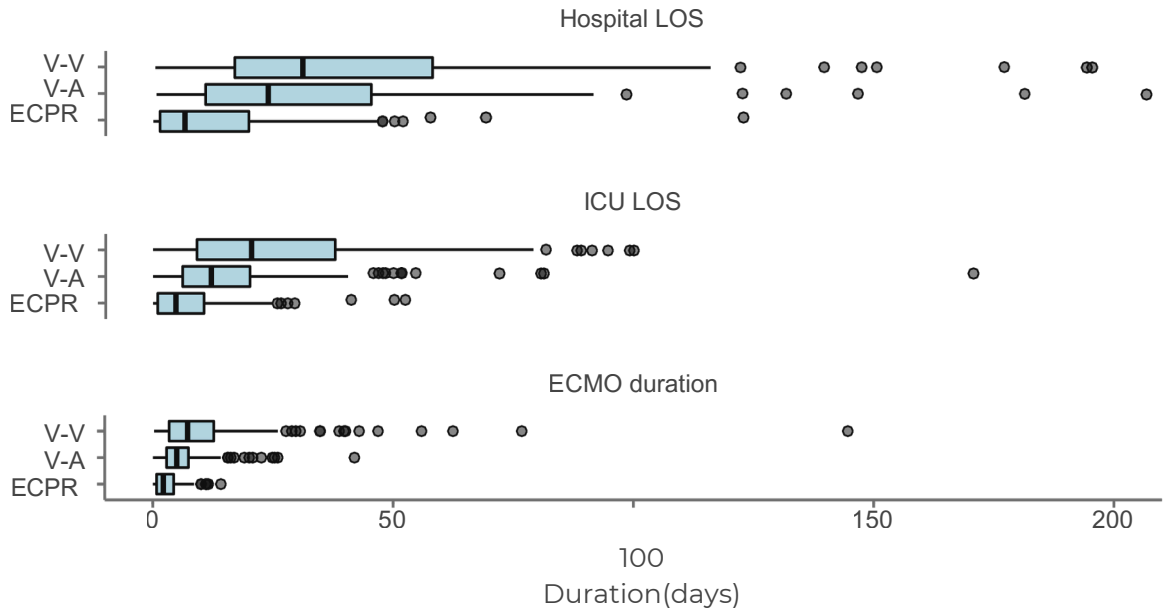

Figure 4: Distribution of length of stay stratified by ECMO mode

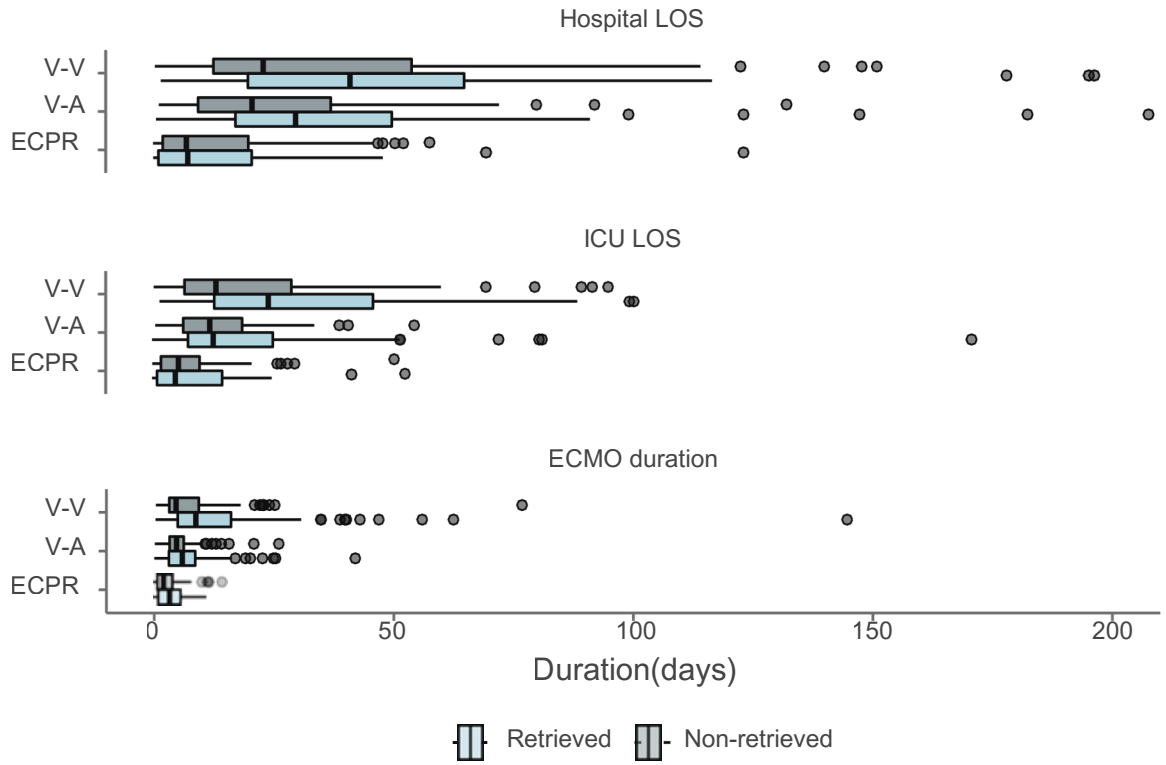

Figure 5: Distribution of length of stay stratified by transfer status

ECMO trips

Table 9: Number of trips while on ECMO stratified by ECMO type

	V-V (N=161)	V-A (N=205)	ECPR (N=107)	Total (N=473)
Number of operative theatre trips[1]				
- Mean (SD)	1.7 (1.5)	2.4 (1.3)	1.9 (1.1)	2.0 (1.3)
- Range	1.0 - 10.0	1.0 - 8.0	1.0 - 6.0	1.0 - 10.0
- Missing	7	22	9	38
Number of radiology trips[1]				
- Mean (SD)	2.5 (2.2)	1.9 (1.5)	2.5 (1.8)	2.2 (1.9)
- Range	1.0 - 13.0	1.0 - 7.0	1.0 - 7.0	1.0 - 13.0
- Missing	9	22	9	40

[1] Trips occur when a patient is physically transferred to another location to facilitate imaging and/or procedure

ECMO discontinuation

Table 10: ECMO discontinuation reason stratified by ECMO type

	V-V (N=161)	V-A (N=205)	ECPR (N=107)	Total (N=473)
ECMO discontinuation reason				
- Expected recovery	116 (72.0%)	141 (68.8%)	43 (40.6%)	300 (63.5%)
- Poor prognosis	40 (24.8%)	59 (28.8%)	62 (58.4%)	161 (34.1%)
- Bridge to VAD	0 (0.0%)	3 (1.4%)	1 (1.0%)	4 (0.8%)
- Bridge to lung transplant	3 (1.9%)	0 (0.0%)	0 (0.0%)	3 (0.6%)
- Bridge to heart transplant	0 (0.0%)	2 (1.0%)	0 (0.0%)	2 (0.4%)
- ECMO complication	2 (1.2%)	0 (0.0%)	0 (0.0%)	2 (0.4%)
- Total	161	205	106	472
- Missing	0	0	1	1

ICU therapies

Table 11: ICU therapies

	V-V (N=161)	V-A (N=205)	ECPR (N=107)
Second ECMO Run			
- Yes	1 (0.6%)	2 (1.0%)	1 (1.0%)
- No	158 (99.4%)	190 (99.0%)	99 (99.0%)
- Missing	2	13	7
Renal Replacement Therapy			
- Yes	87 (54.4%)	128 (63.4%)	55 (52.3%)
- No	73 (45.6%)	74 (36.6%)	50 (47.7%)
- Missing	1	3	2

COMPLICATIONS

Table 12: Proportion of patients with complications

Complications category	
Pulmonary	8.1%
Renal	76.2%
Cardiovascular	55.4%
Infection	48.5%
Bleeding	38.2%
Mechanical	13.2%
Neurological	12.0%

Major complications are reported to the registry under 7 main categories, renal, cardiovascular, bleeding, infection, mechanical, neurological and pulmonary (Table 12). The most common complications were Renal (76.2%), Cardiovascular (55.4%), Infection (48.5%) and Bleeding (38.2%).

Figures 6, 7 and 8 report complications for each type of ECMO (VV-ECMO, VA-ECMO and ECPR). Renal replacement therapy was the most common complication across all types of ECMO, but for VV-ECMO lung infection was reported for over 40% of cases, and for VA-ECMO and ECPR cardiac arrythmia were among the most common complications.

Figure 9 describes the differences in major complications between patients who were retrieved and non-retrieved. Patient oxygenator failure and deep vein thrombosis (DVT) were more common in retrieved patients.

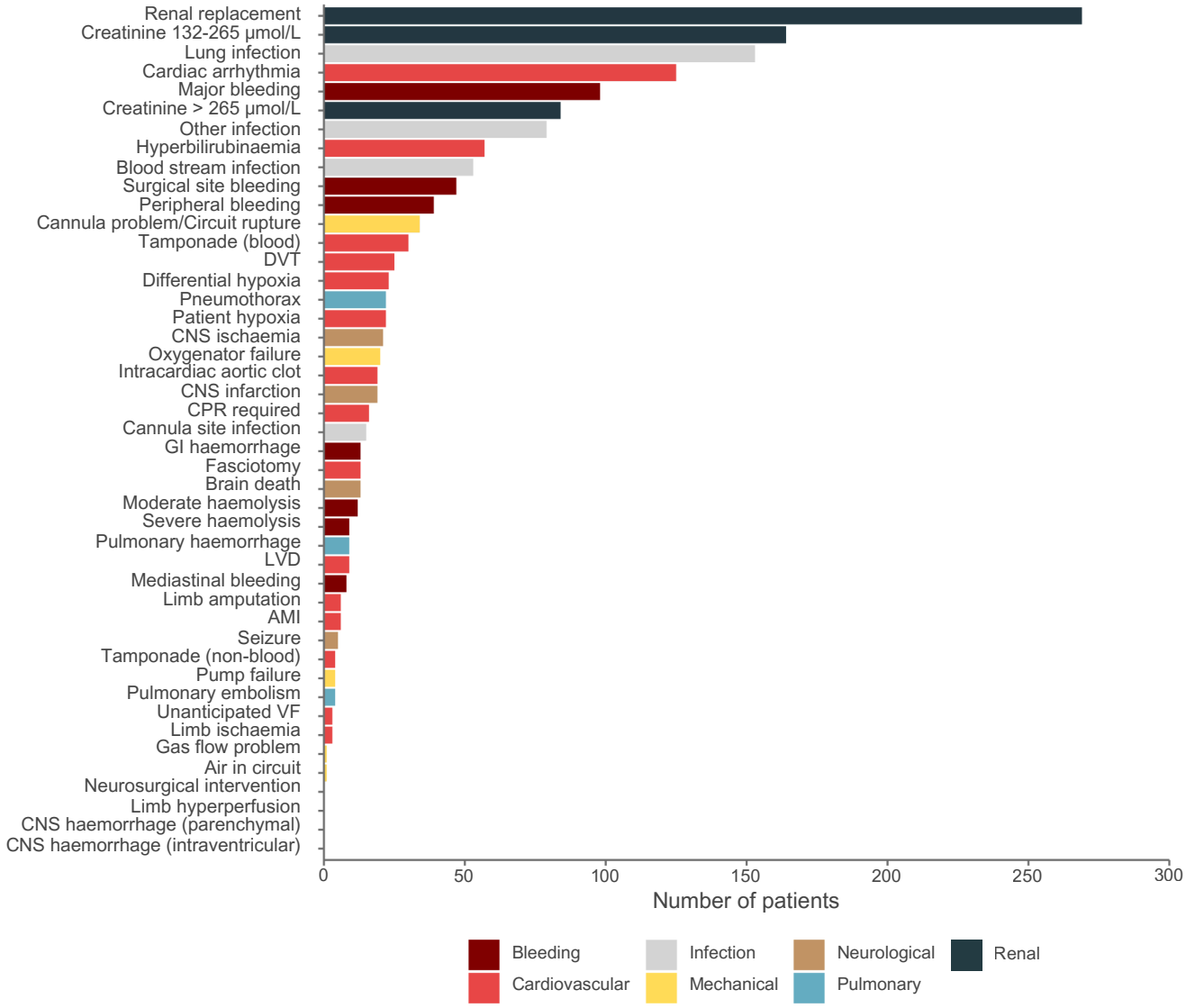

Figure 6: Distribution of post-ECMO complications

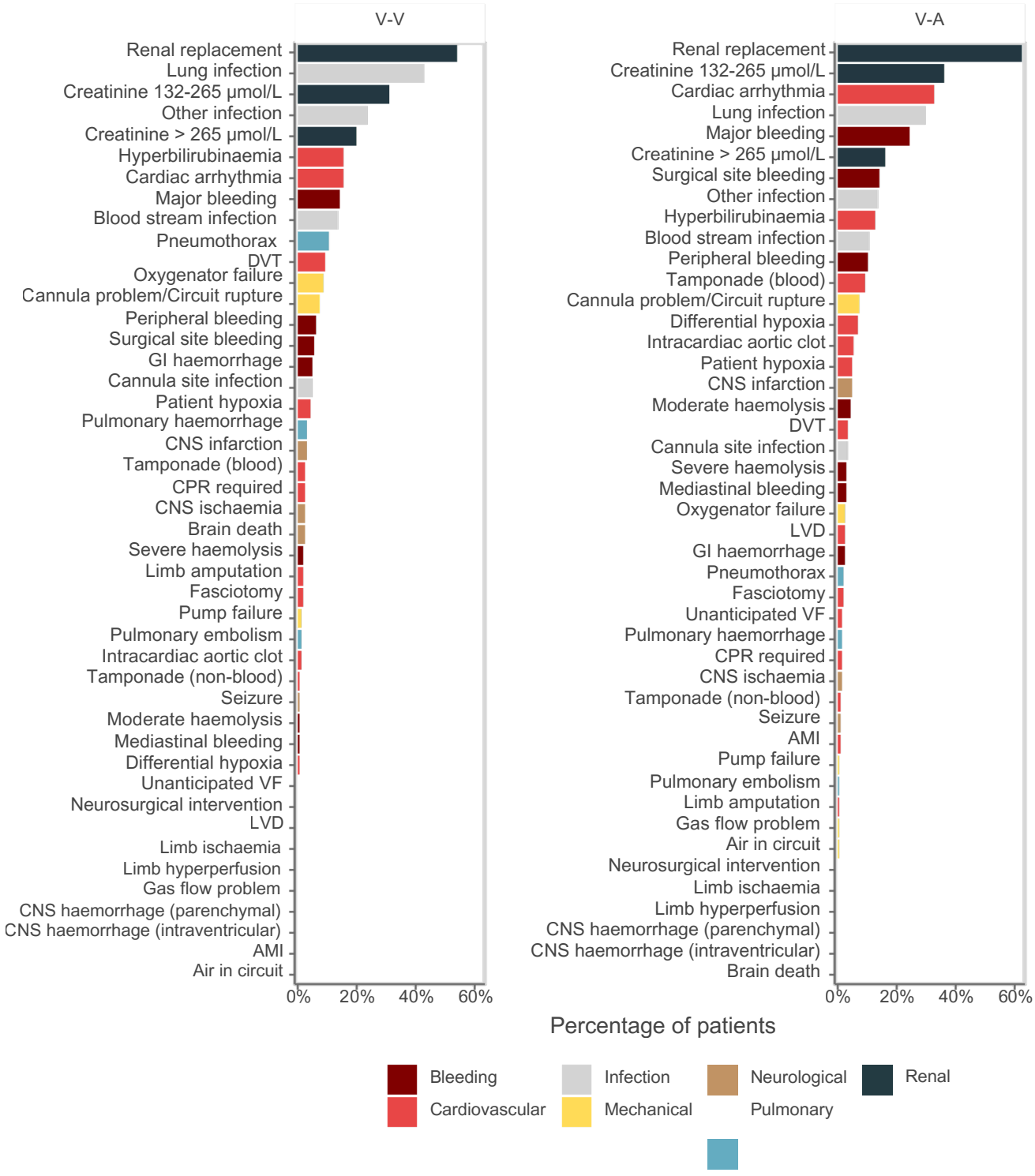

Figure 7: Distribution of post-ECMO complications stratified by ECMO mode (V-V and V-A)

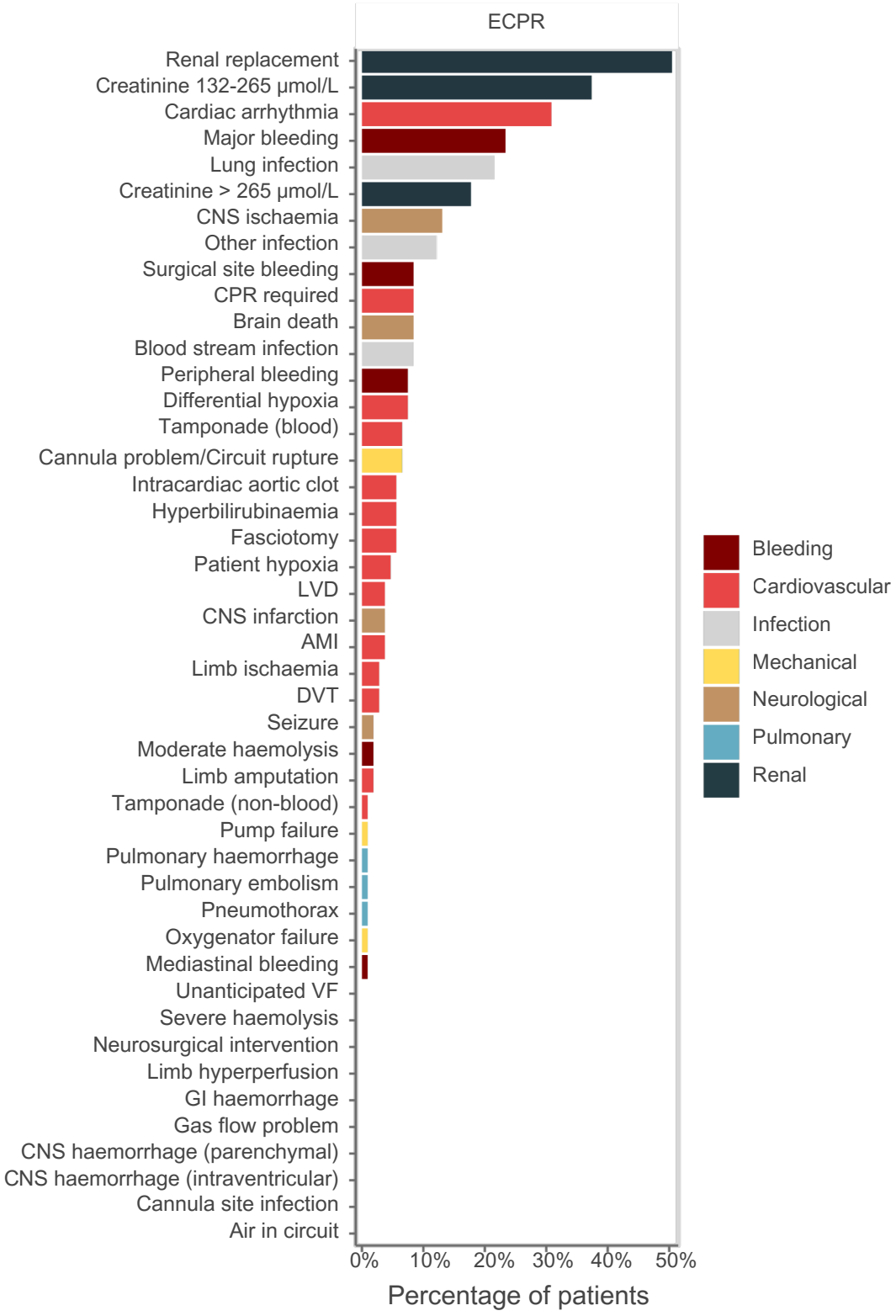

Figure 8: Distribution of post-ECMO complications stratified by ECMO mode (ECPR)

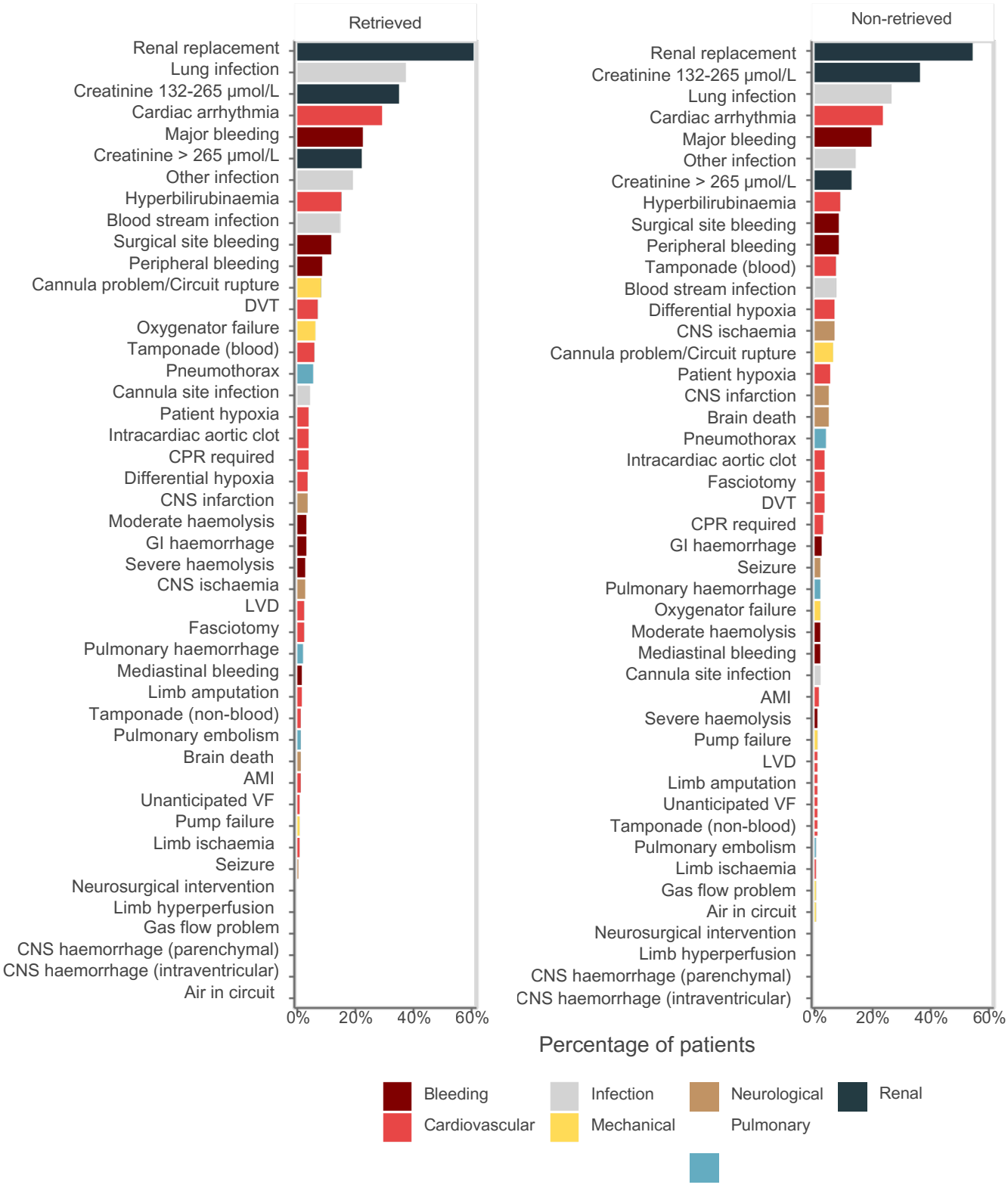

Figure 9: Distribution of post-ECMO complications stratified by transfer status

OUTCOME DATA

Proximate cause of death

Table 13: Proximate cause of death stratified by ECMO type

	V-V (N=161)	V-A (N=205)	ECPR (N=107)	Total (N=473)
Proximate cause of death				
- Cardiogenic shock	0 (0.0%)	38 (51.4%)	19 (27.5%)	57 (29.5%)
- Other	13 (26.0%)	13 (17.6%)	11 (15.9%)	37 (19.2%)
- Distributive (Septic) shock	13 (26.0%)	6 (8.1%)	4 (5.8%)	23 (11.9%)
- Neurological no TBI without brain death	4 (8.0%)	9 (12.2%)	10 (14.5%)	23 (11.9%)
- Hypoxic respiratory failure	15 (30.0%)	3 (4.1%)	2 (2.9%)	20 (10.4%)
- Neurological no TBI with brain death	5 (10.0%)	1 (1.4%)	12 (17.4%)	18 (9.3%)
- Arrhythmia	0 (0.0%)	1 (1.4%)	8 (11.6%)	9 (4.7%)
- Hypovolaemic shock	0 (0.0%)	2 (2.7%)	2 (2.9%)	4 (2.1%)
- Metabolic	0 (0.0%)	1 (1.4%)	1 (1.4%)	2 (1.0%)
- Total	50	74	69	193

The most common cause of death was cardiogenic shock 57 (29.5%) and other 37 (19.2%). There were 18 (9.3%) patients who suffered a neurological event that resulted in brain death during or after ECMO. A further 23 (11.9%) died because of a neurological event that did not cause brain death.

Discharge destination

Table 14: Discharge destination post-ECMO stratified by ECMO type

	V-V (N=161)	V-A (N=205)	ECPR (N=107)	Total (N=473)
ICU discharge destination				
- Ward	83 (52.5%)	113 (58.2%)	27 (26.5%)	223 (49.1%)
- Deceased	48 (30.4%)	70 (36.1%)	68 (66.7%)	186 (41.0%)
- Other hospital ICU	24 (15.2%)	10 (5.2%)	4 (3.9%)	38 (8.4%)
- Other ICU, same hospital	3 (1.9%)	0 (0.0%)	1 (1.0%)	4 (0.9%)
- Home	0 (0.0%)	1 (0.5%)	1 (1.0%)	2 (0.4%)
- Other	0 (0.0%)	0 (0.0%)	1 (1.0%)	1 (0.2%)
- Total	158	194	102	454
- Missing	3	11	5	19
Hospital discharge destination				
- Deceased	51 (31.9%)	79 (38.5%)	77 (72.0%)	207 (43.9%)
- Home	47 (29.4%)	61 (29.8%)	18 (16.8%)	126 (26.7%)
- Transferred to another hospital	40 (25.0%)	31 (15.1%)	8 (7.5%)	79 (16.7%)
- Transferred to rehab	22 (13.8%)	33 (16.1%)	4 (3.7%)	59 (12.5%)
- Other	0 (0.0%)	1 (0.5%)	0 (0.0%)	1 (0.2%)
- Total	160	205	107	472
- Missing	1	0	0	1

Overall, most patients were discharged from ICU to the ward 223 (49.1%), but 186 (41.0%) were deceased and 38 (8.4%) were discharged to the ICU in another hospital. After hospital discharge, only 126 (26.7%) were discharged home while 59 (12.5%) were transferred to a rehabilitation facility.

Survival

We have shown survival to 180-days in Kaplan-Meier plots stratified by type of ECMO (Figure 10) and by type of ECMO and retrieval status (Figure 11). Patients receiving VV-ECMO are most likely to survive overall and patients receiving ECPR are least likely to survive.

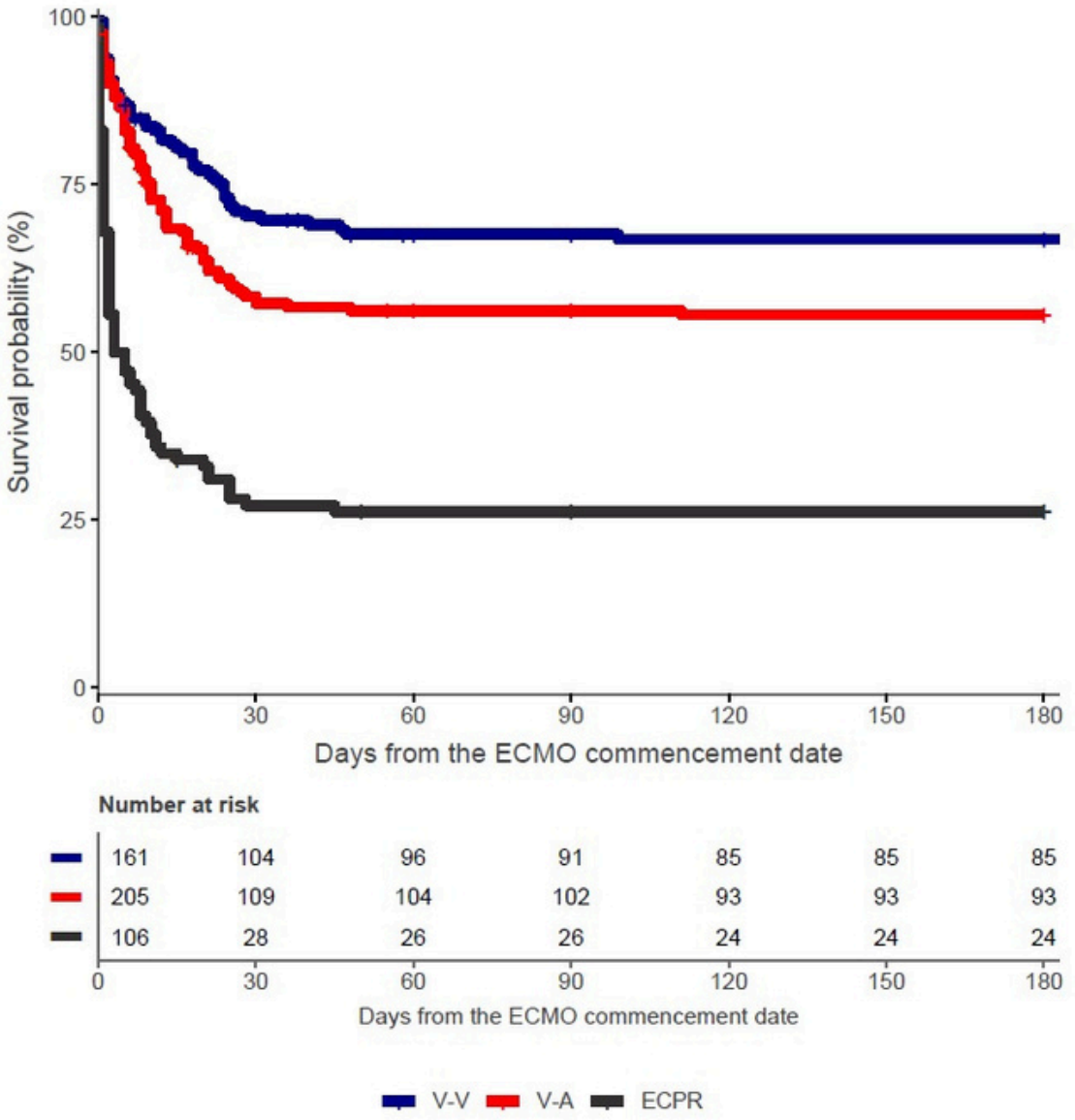

Figure 10: Kaplan-Meier plot of survival stratified by ECMO type

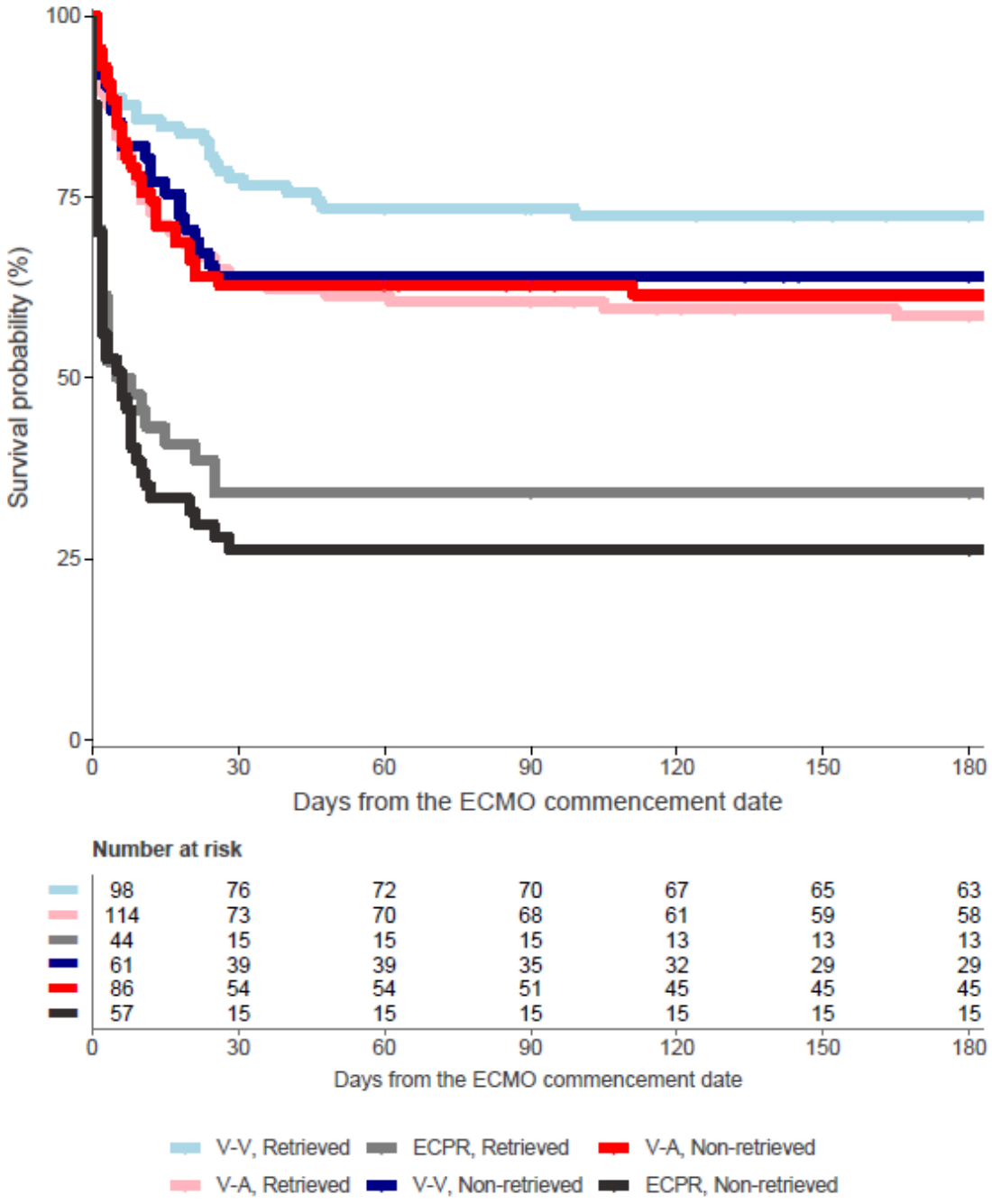

Figure 11: Kaplan-Meier plot of survival stratified by transfer status and ECMO type

Funnel plots

We provide standardised mortality ratio for VV-patients (using the RESP score), for VA-patients (using the SAVE score) and for ECPR patients (also using the SAVE score). Each dot represents a site, and the outer limits represent the 95% and the 99.8% control limits. In reports to each site biannually, the site is identified using a different colour to allow interpretation of outliers.

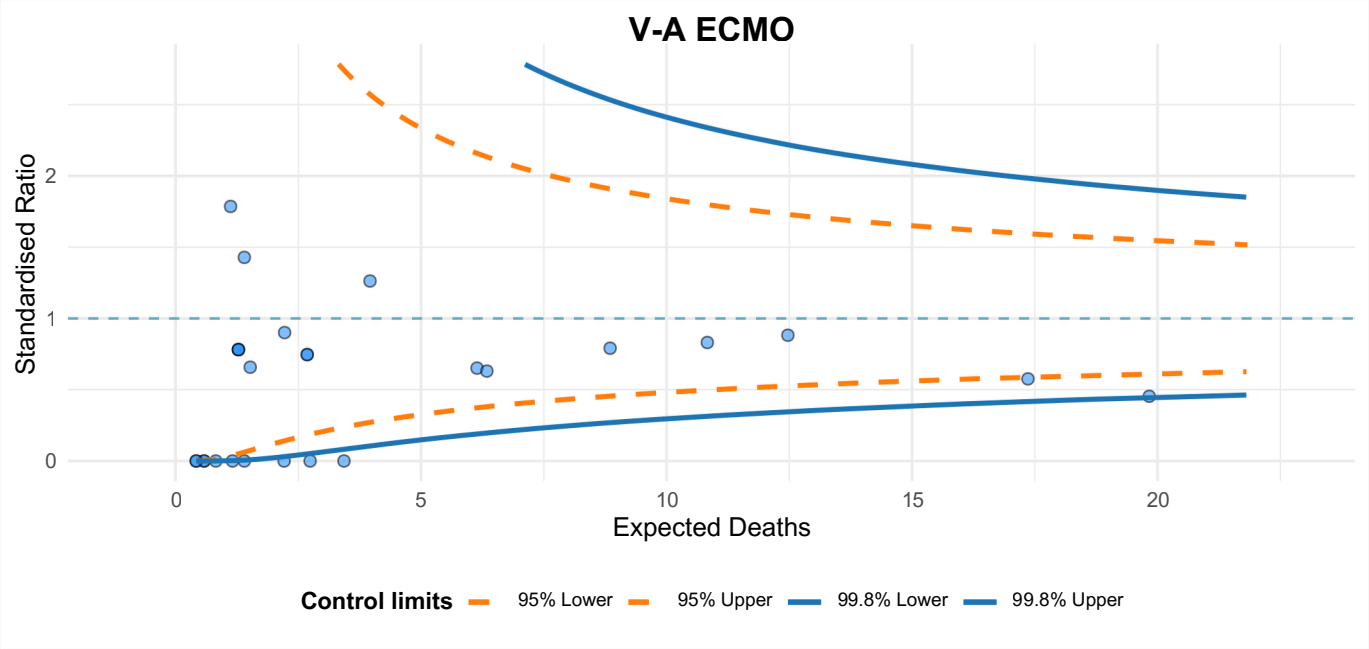

Figure 12: Risk adjusted standardized mortality rate for V-A patients. Values above 1 indicate higher expected. mortality than

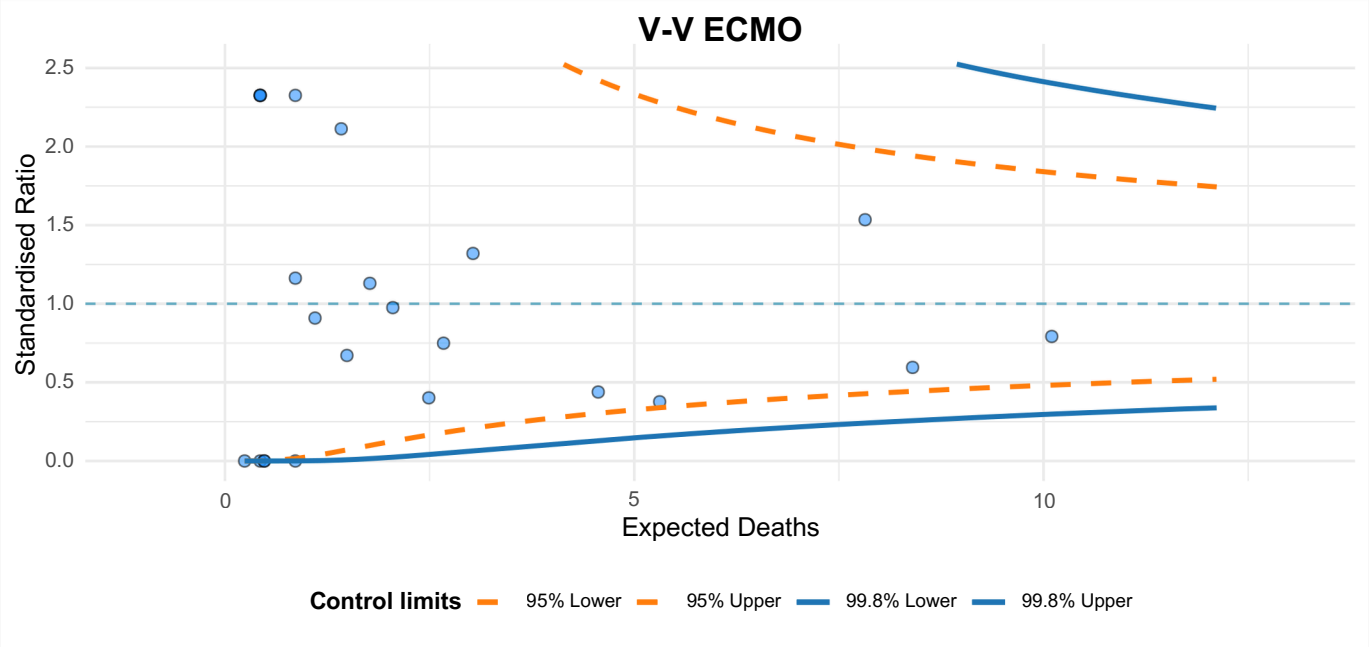

Figure 13: Risk adjusted standardized mortality ratio for V-V patients. Values above 1 indicate higher mortality than expected.

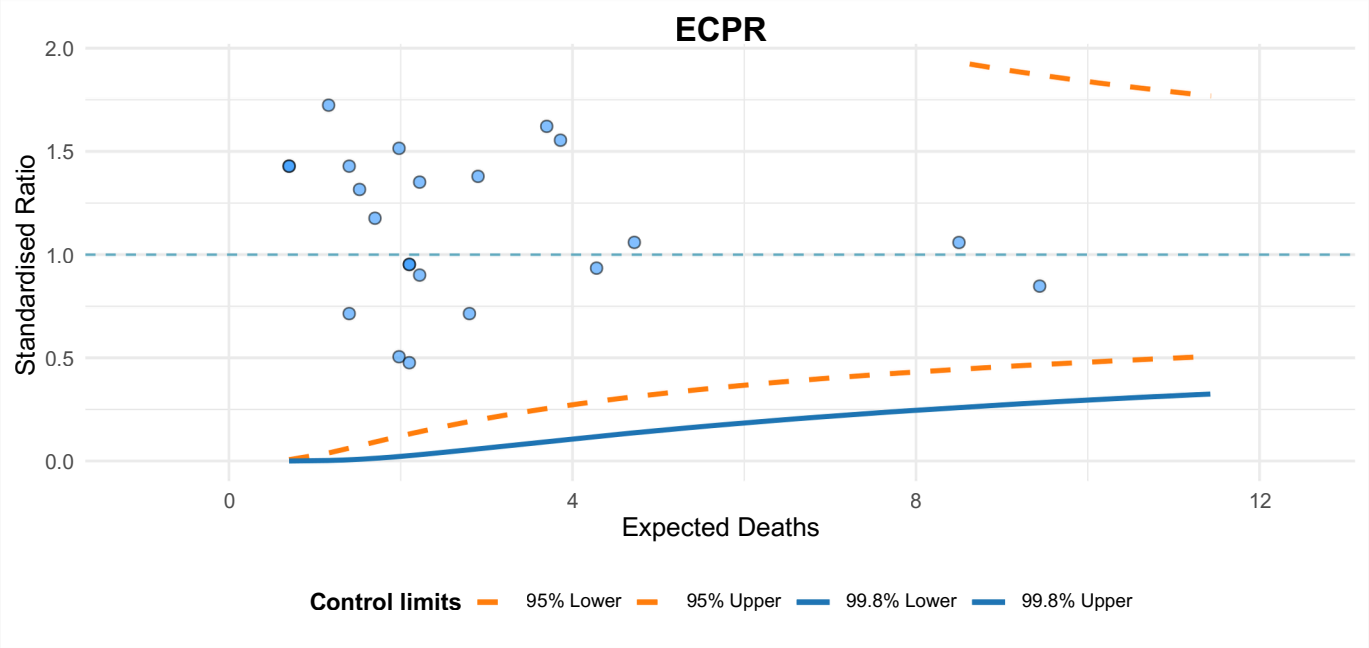

Figure 14: Risk adjusted standardized mortality ratio for ECPR patients. Values above 1 indicate higher mortality than expected.

FOLLOW-UP (6 months post ECMO)

We follow-up each surviving patient at 6 and 12 months after ECMO initiation by telephone from the Australian and New Zealand Intensive Care Research Centre using trained personnel. Each call is monitored for quality purposes. The patient reported outcome measures (PROMS) used include:

- The *Lawton IADL Scale* is a valid and reliable functional assessment instrument which assesses independent living skills across 8 domains of function. A summary score ranges between 0 and 8 with higher scores indicating greater levels of independence.

- The *Barthel Index* measures functional disability in 10 ADLs by quantifying patient performance. 5-point increments are used in scoring, with a maximal score of 100 indicating full independence in physical functioning whilst a lowest score of 0 indicating a patient with a complete bed-bound state.

- The EQ-*5D-5L* is a generic preference-based instrument that measures health related quality of life. It is comprised of five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The EQ Visual Analogue Scale provides a single global rating of self-perceived health and is scored on a 0 to 100 scale representing "the worst…" and "the best health you can imagine", respectively.

- The 12-item *WHODAS 2.0 score* scores from 0 (no difficulty) to 4 (extreme difficulty) for each item and a total WHODAS score ranges from 0 to 48, with higher scores representing greater disability. The total score is divided by 48 and multiplied by 100 to convert it into a percentage of maximum disability.

Table 15: Follow-up functional outcome measures and ECMO mode

	V-V (N=304)	V-A (N=316)	ECPR (N=255)	Total (N=875)
WHODAS 2.0 12L				
- Mean (SD)	24.4 (21.8)	24.4 (21.5)	24.2 (21.4)	24.3 (21.6)
- Median (IQR)	18.8 (6.2, 39.6)	18.8 (6.2, 37.5)	18.8 (6.2, 37.5)	18.8 (6.2, 37.5)
- Range	0.0 - 100.0	0.0 - 100.0	0.0 - 100.0	0.0 - 100.0
- Missing	33	34	27	94
IADL				
- Mean (SD)	6.7 (1.9)	6.7 (2.0)	6.8 (1.9)	6.7 (2.0)
- Median (IQR)	8.0 (6.0, 8.0)	8.0 (6.0, 8.0)	8.0 (6.0, 8.0)	8.0 (6.0, 8.0)
- Range	0.0 - 8.0	0.0 - 8.0	0.0 - 8.0	0.0 - 8.0
- Missing	55	62	46	163
Barthel index				
- Mean (SD)	95.5 (13.1)	95.2 (13.9)	95.4 (13.4)	95.3 (13.5)
- Median (IQR)	100.0 (100.0, 100.0)	100.0 (100.0, 100.0)	100.0 (100.0, 100.0)	100.0 (100.0, 100.0)
- Range	0.0 - 100.0	0.0 - 100.0	0.0 - 100.0	0.0 - 100.0
- Missing	52	57	44	153
Health related quality of life				
- Mean (SD)	68.1 (20.1)	68.7 (20.2)	68.3 (20.1)	68.4 (20.1)
- Median (IQR)	70.0 (60.0, 80.0)	70.0 (60.0, 85.0)	70.0 (60.0, 82.0)	70.0 (60.0, 85.0)
- Range	5.0 - 100.0	1.0 - 100.0	5.0 - 100.0	1.0 - 100.0
- Missing	32	33	26	91

While recovery at 6-months is variable, the majority of survivors report mild to moderate disability. This is despite being able to independently manage their daily activities. Health related quality of life is similar to other survivors of critical illness.

This follow-up dataset comprises patients who began ECMO treatment between 2019 and 2023 and survived to 180 days following ECMO initiation.

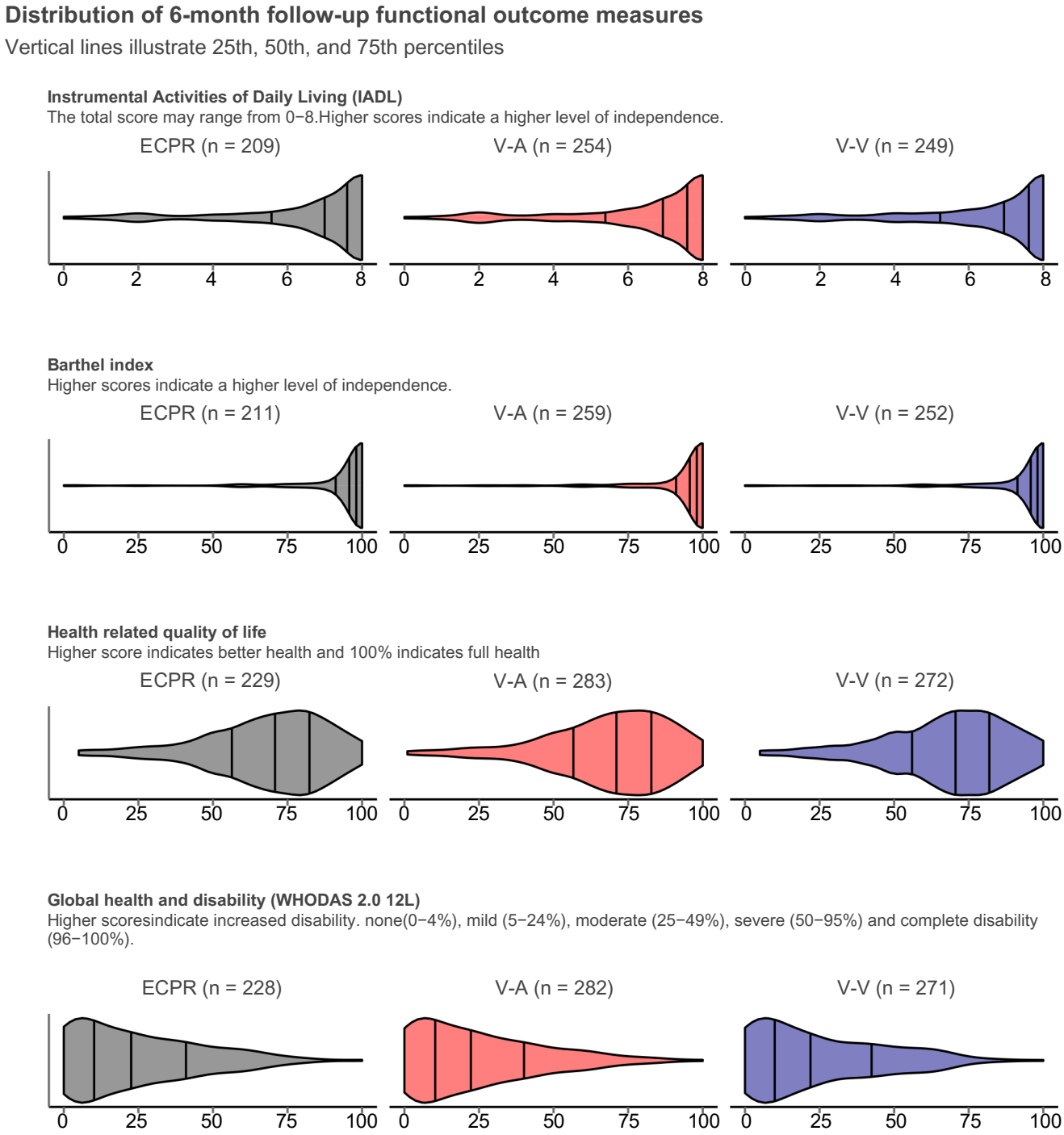

Figure 15: Distribution of follow-up functional outcome measures and ECMO mode

COVID-19 PATIENTS

In 2020 we added additional data points to determine the use of ECMO in patients with COVID-19, aligned with the data in the international registry (ELSO). There were 18 (4%) patients who were diagnosed with COVID-19 who received ECMO in this period. Patients with COVID-19 had a longer duration of ECMO, longer ICU and hospital length of stay (Figure 17). Survival of patients with COVID-19 was lower than other patients on VV-ECMO (Figure 19).
Figure 16 refers to 4 year period.

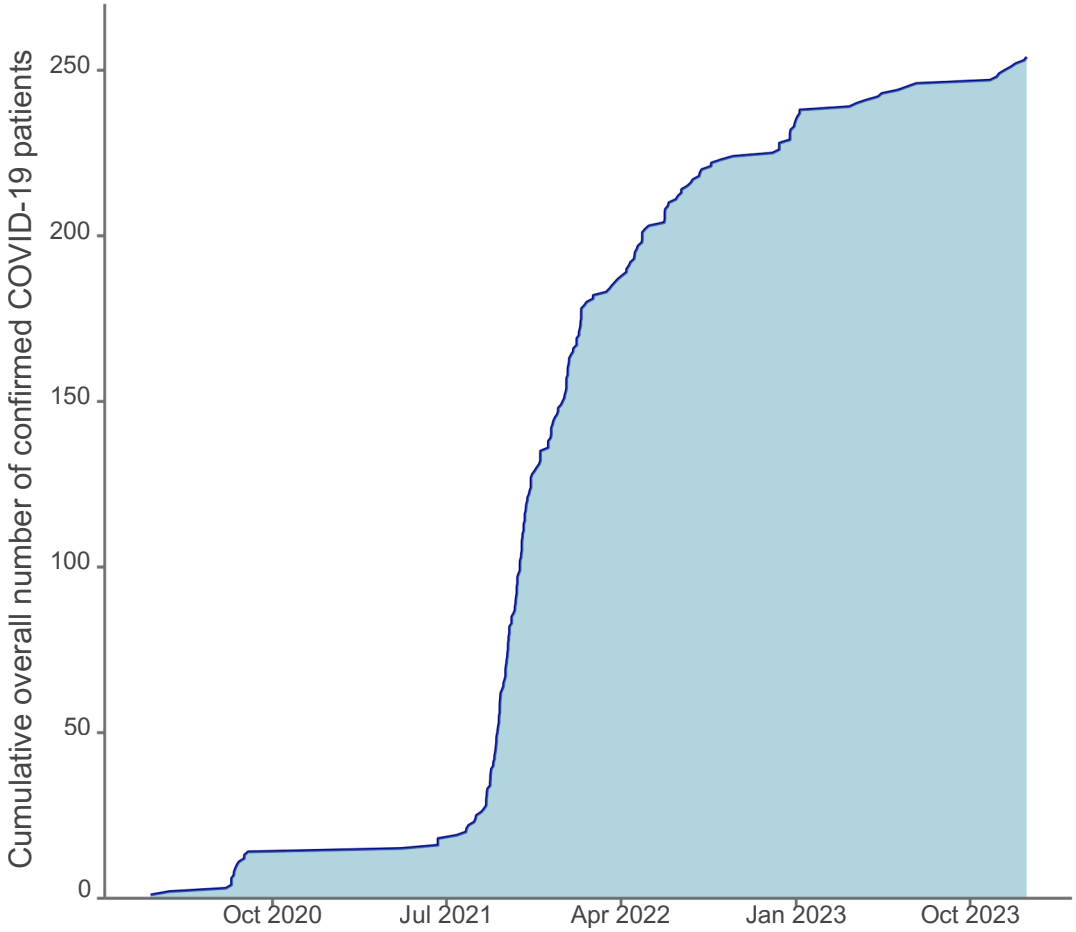

Figure 16: Cumulative overall confirmed COVID-19 patients

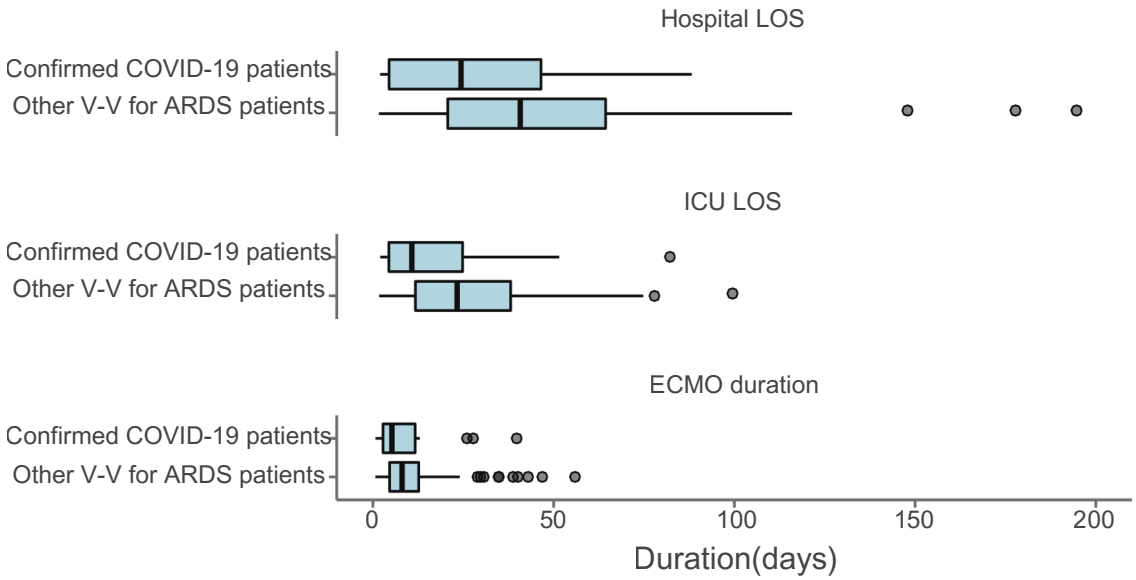

Figure 17: Distribution of length of stay stratified by COVID-19 status

Table 16: Discharge destination post-ECMO stratified by COVID-19 status

	Confirmed COVID-19 patients (N=18)	Other V-V for ARDS patients (N=90)	Total (N=108)
ICU discharge destination			
- Ward	6 (33.3%)	43 (47.8%)	49 (45.4%)
- Deceased	11 (61.1%)	23 (25.6%)	34 (31.5%)
- Other hospital ICU	1 (5.6%)	21 (23.3%)	22 (20.4%)
- Other ICU, same hospital	0 (0.0%)	3 (3.3%)	3 (2.8%)
- Total	18	90	108
- Missing	0	0	0
Hospital discharge destination			
- Deceased	11 (61.1%)	24 (26.7%)	35 (32.4%)
- Transferred to another hospital	3 (16.7%)	31 (34.4%)	34 (31.5%)
- Home	4 (22.2%)	22 (24.4%)	26 (24.1%)
- Transferred to rehab	0 (0.0%)	13 (14.4%)	13 (12.0%)
- Total	18	90	108
- Missing	0	0	0

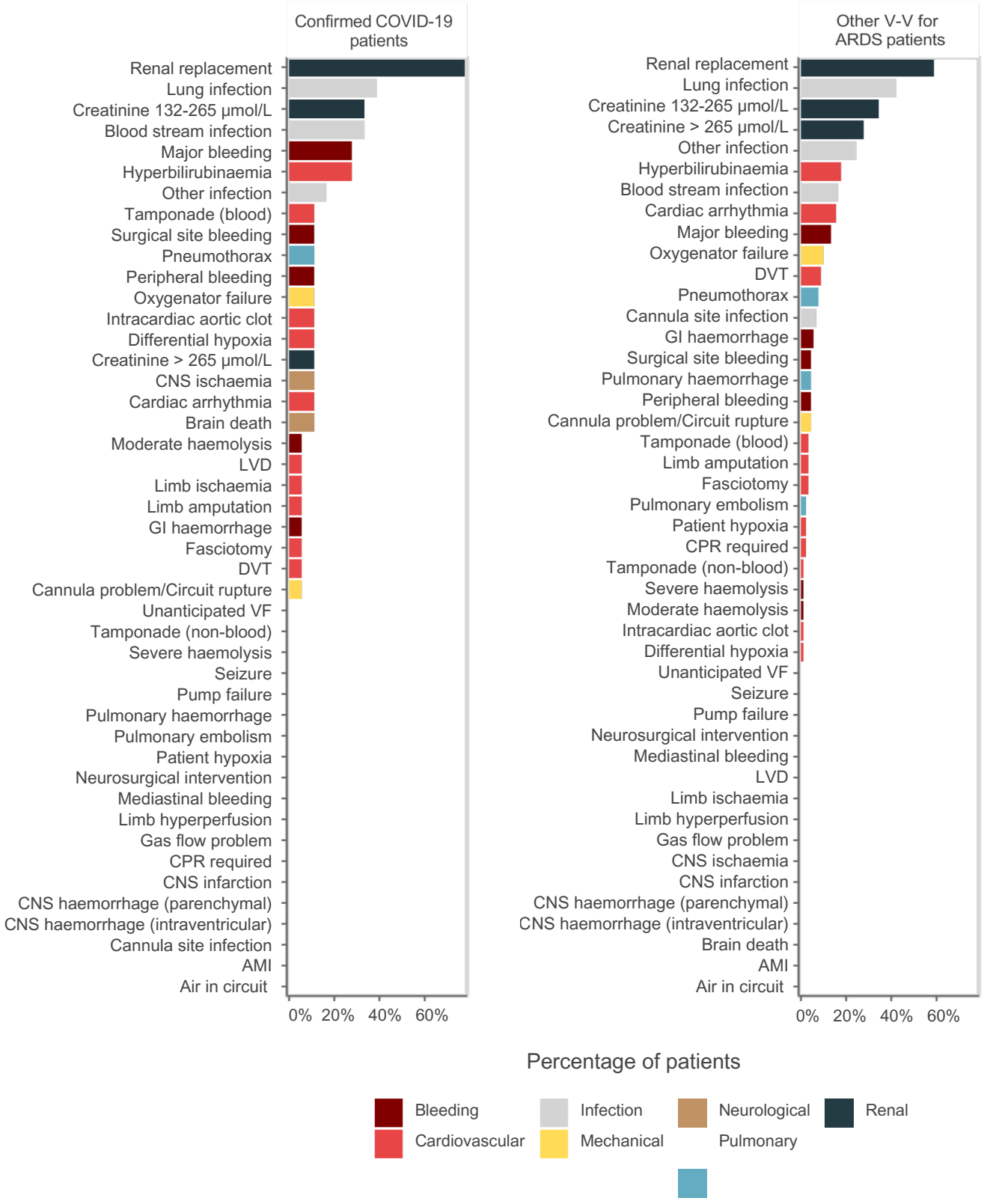

Figure 18: Distribution of post-ECMO complications stratified by COVID-19 status over the year of 2023

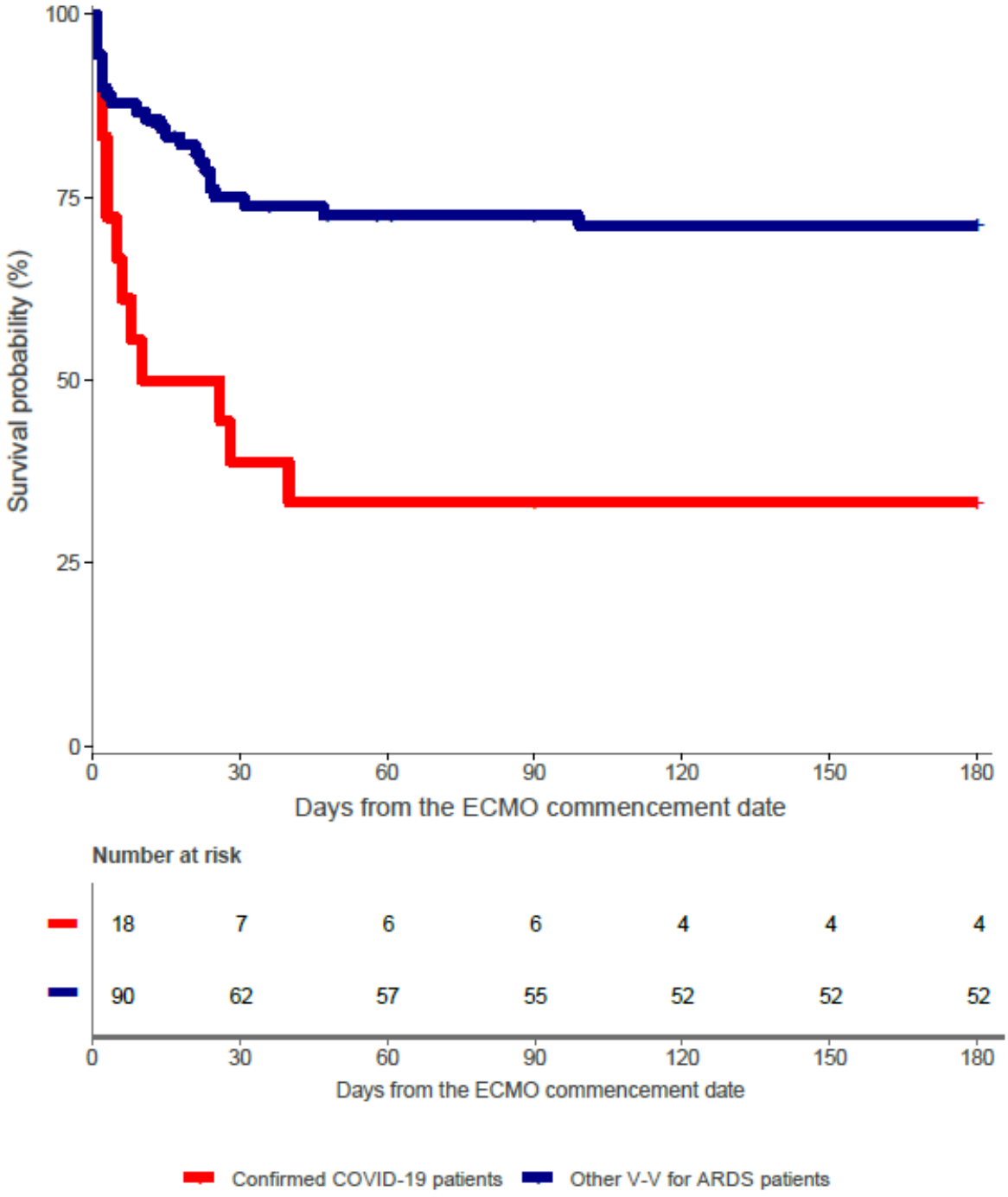

Figure 19: Kaplan-Meier plot of survival stratified by COVID-19 status over the year of 2023

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11. Dennis, M., Shekar, K., & Burrell, A. J. C., for the National ECPR Working Group. (2023). Extracorporeal cardiopulmonary resuscitation for refractory cardiac arrest in Australia: A narrative review. **Medical Journal of Australia**. Advance online publication. https://doi.org/10.5694/mja2.52130
12. Stephens, A. F., Šeman, M., Diehl, A., Pilcher, D., Barbaro, R. P., Brodie, D., Pellegrino, V., Kaye, D. M., Gregory, S. D., & Hodgson, C., on behalf of the Extracorporeal Life Support Organization Member Centres. (2023). ECMO PAL: Using deep neural networks for survival prediction in venoarterial extracorporeal membrane oxygenation. **Intensive Care Medicine**, 49, 1090–1099. https://doi.org/10.1007/s00134-023-07075-3

APPENDIX

Complications

The EXCEL Registry currently collects a range of complications that both clinicians and researchers feel is important to know when a patient undergoes ECMO. This data will help to drive both improvement and identification of complications that present most notability within specific ECMO populations, as well as the ECMO cohort as a whole. The definitions for these complications have recently been updated with regard to new research evidence decided upon by the international ECMO community (e.g. core outcome set - Hodgson et al, Crit Care Med, 2021).

The complications captured by EXCEL are listed below.

Mechanical Complications

Relates directly to components within the ECMO circuit that are used to deliver extracorporeal support.

These include:
- Oxygenator and pump failure requiring exchange of these components
- Cannula problems and circuit rupture.
- Formation of clots within the circuit's components (connectors, bridges, pigtails) or within the haemofilter itself
- Disruption of gas flow and air within the circuit
- Heat exchanger malfunction

Haemorrhagic Complications

Due to the high acuity and often post-operative status of these patients, we collect an extensive range of bleeding complications.

These include:
- GI haemorrhage (upper or lower GI)
- Peripheral and mediastinal site bleeding.
- Surgical site bleeding (other than the cannulation sites)
- Major bleeding which can include fatal or symptomatic bleeds within critical areas or regions, as well as whether a fall in haemoglobin or transfusion has been performed.

Renal Complications

These include:
- Creatinine serum measurement of >132.
- Use of renal replacement therapy

Cardiovascular Complications

A large proportion of ECMO patients undergo intervention based upon a cardiovascular-related diagnosis. The following complications seek to elucidate further development of cardiac conditions.

These include:
- Cardiac arrest requiring CPR
- Cardiac arrythmia requiring antiarrhythmic medications, overdrive pacing, cardioversion or defibrillation
- Tamponade.
- Acute myocardial infarction.
- Left ventricular distension requiring decompression of the left ventricle after initiation of VA-ECMO
- Unanticipated ventricle fibrillation.
- Intracardiac/aortic clot confirmed by echocardiography

Pulmonary Complications

- Pneumothorax requiring insertion of chest drain
- Pulmonary haemorrhage requiring a packed red blood cell transfusion
- Pulmonary embolism diagnosed with contrast angiography, ventilation perfusion scan, isotope scanning or CTPA.

Metabolic Complications

ECMO patients are also noted to undergo serious metabolic changes and complications during the intervention.

- Hyperbilirubinemia – Based on total bilirubin or conjugated bilirubin, or the need for extracorporeal purification
- Moderate and severe haemolysis – Peaks in plasma haemoglobin sustained for 2 recordings 4 hours apart
- Patient hypoxia – With an oxygen saturation level below 80% lasting more than 5 minutes or requiring an emergency response.
- Differential hypoxia – Lower oxygen saturation readings on one side of the body when compared to the other

Limb Complications

Extended stays within ICU as well as peripheral limb cannulation sites can develop into a number of limb complications for the ECMO patient.

- Fasciotomy – Performed secondary to compartment syndrome from ECMO cannulation
- Pressure injury – Localised damage to the skin and underlying tissue caused by pressure or shearing force
- Limb amputation – Secondary to complications experienced during ECMO run
- Limb ischaemia requiring limb perfusion cannula – Post peripheral cannulation, requiring addition of limb reperfusion cannula within 6 hours of cannulation
- Deep vein thrombosis – Diagnosed with imaging (ultrasound or venography)
- Limb hyper-perfusion – Caused by the ECMO cannula, causing increased blood flow in a limb

Neurological Complications

- Brian death or neurological determination of death
- Seizures clinically determined
- Seizures confirmed by EEG
- CNS diffuse ischaemia – CT or MRI demonstrating ischaemic changes
- CNS infarction (US or CT or MRI) OR thrombotic/embolic CVA
- Intracranial haemorrhage – Acute neurological deficit attributable to intracranial haemorrhage
- Neurological intervention performed – For example, intracranial pressure monitor or external ventricular drain inserted

Other Complications

This is a free text field within the database in which we give clinicians the ability to enter in any other complication they believe are a result of the patient being on ECMO. This has assisted in identification and addition of new complications that were not previously available, but that have been found to occur frequently within this patient cohort.