EMA Emergency Medicine Australasia

Emergency Medicine Australasia (2022) **34**, 452–455 doi: 10.1111/1742-6723.13972

SHORT REPORT

Out-of-hospital cardiac arrest outcomes, end-tidal carbon dioxide and extracorporeal cardiopulmonary resuscitation eligibility: New South Wales pilot data

Mark DENNIS, on behalf of the RESET Study Group and Sydney ECMO Research Interest Group

Department of Cardiology, Royal Prince Alfred Hospital, Sydney, New South Wales, Australia

Abstract

Objective: To describe on-scene times for out-of-hospital cardiac arrests (OHCA) transferred to hospital, the number of these that were extracorporeal cardiopulmonary resuscitation (ECPR) eligible and potential association between end-tidal carbon dioxide ($ETCO_2$) and survival so as to inform planned interventional studies.

Methods: Prospective cohort study of all OHCA, of suspected medical cause, where resuscitation was commenced and who were transported to participating hospitals from October 2020 to May 2021.

Results: One hundred and forty-nine OHCA were included. Forty-four (30%) patients survived to hospital discharge. Eighteen (8%) met ECPR inclusion criteria. Median on-scene time was 33 min (interquartile range [IQR] 24–44). Initial hospital $ETCO_2$ for non-survivors was 35 mmHg (IQR 19–50), survivors 36 mmHg (IQR 33–45); $P = 0.215$. No patient with an $ETCO_2$ less than 20 mmHg on hospital arrival to survived to hospital discharge.

Conclusions: Average on-scene time did not differ on survivorship. A small number of transferred patients with OHCA were ECPR eligible. $ETCO_2$ less than 20 mmHg portends adverse prognosis. Our data will be used for future interventional studies.

Key words: *ECPR, end-tidal carbon dioxide, $ETCO_2$, out-of-hospital cardiac arrest, scene time.*

Introduction

Survival from out-of-hospital cardiac arrest (OHCA) remains low.[1] There continues to be considerable uncertainty regarding the clinical utility of expedited patient transfer from the scene of OHCA,[2] the prognostic value of end-tidal carbon dioxide ($ETCO_2$) during cardiopulmonary resuscitation (CPR)[3] and indications for extracorporeal membrane oxygenation (ECMO) in cardiac arrest (extracorporeal cardiopulmonary resuscitation [ECPR]). In order to inform planned interventional studies, we performed a pilot study to examine the scene times, the number of potential ECPR cases and association between $ETCO_2$ and survivorship.

Methods

Study design and methods

Prospective cohort study of all OHCA of suspected medical cause, aged 16 years and older, where resuscitation was commenced, who were transported to a participating hospital from October 2020 to May 2021 inclusive. Data collection was standardised across participating hospitals. All OHCA were prospectively identified by participating hospitals and was cross-referenced with NSW Ambulance cardiac arrest registry data to ensure completeness of arrest cases and arrest data. All hospitals standardised ECPR eligibility criteria prior to study commencement.

Ethical approval statement

Completed under Sydney Local Health District Research ethics and governance (ref: 2020/ETH01162).

Results

Six hundred and fifty-seven arrests occurred within transfer proximity to the participating hospitals. Of these 149 OHCA patients were transferred to a participating hospital and enrolled; median age of 61 years (interquartile range [IQR] 49–73). Baseline characteristics and cardiac arrest details are shown in Table 1. Forty-four (30%) patients survived to hospital discharge, 37 (84%) of which with a cerebral performance category of 1 or 2. No cases with initial rhythm of asystole and two cases with pulseless electrical activity survived to discharge. Return of spontaneous circulation occurred within 20 min of professional resuscitation

Correspondence: Dr Mark Dennis, Department of Cardiology, Royal Prince Alfred Hospital, Missenden Road, Camperdown, Sydney, NSW 2050, Australia. Email: mark.dennis@sydney.edu.au

Mark Dennis, MBBS (Hons), PhD, Cardiologist, Clinical Associate Professor.

†The members of the RESET Study Group are listed in the Acknowledgements section.

Accepted 10 March 2022

TABLE 1. *Patient demographics and baseline characteristics*

Variable	Total ($n = 149$)	Non-survivors ($n = 115$)	Survivors ($n = 44$)	*P*-value
Demographics				
Median age, years (IQR)	61 (49–73)	61 (49–73)	58 (49–70)	0.46
Male, *n* (%)	121 (76%)	87 (76%)	34 (77%)	0.899
Body mass index (kg/m^2), median (IQR)	27 (24–31)	28 (24–31)	27 (23–31)	0.463
Pre-hospital arrest data				
Arrest location				
Home, *n* (%)	106 (67%)	84 (76%)	22 (52%)	0.005
Office, *n* (%)	7 (4%)	6 (6%)	1 (2%)	
Nursing home, *n* (%)	2 (1%)	1 (1%)	1 (2%)	
Sporting and recreation, *n* (%)	12 (8%)	4 (4%)	8 (19%)	
Public building, *n* (%)	25 (16%)	15 (14%)	10 (24%)	
Initial rhythm				
VF, *n* (%)	79 (50%)	46 (40%)	33 (75%)	0.001
VT, *n* (%)	10 (6%)	4 (4%)	6 (14%)	
PEA, *n* (%)	37 (23%)	36 (31%)	1 (2%)	
Asystole, *n* (%)	28 (18%)	26 (23%)	2 (5)	
Time to defibrillation, min (IQR)	12 (5–16)	14 (11–17)	7 (3–14)	0.001
Witnessed arrest, *n* (%)	133 (84%)	92 (80%)	41 (93%)	0.04
Bystander CPR, *n* (%)	141 (89%)	102 (89%)	39 (89%)	0.992
Time to bystander CPR: immediate, *n* (%)	91 (70%)	63 (54%)	28 (85%)	0.131
Time to bystander CPR: 1–5 min, *n* (%)	24 (18%)	20 (17%)	4 (10%)	0.131
ST elevation on initial ECG, *n* (%)	33 (21%)	19 (17%)	14 (32%)	0.036
Pre-hospital $ETCO_2$ recorded, *n* (%)	80 (50%)	61 (54%)	19 (43%)	0.203
Pre-hospital first $ETCO_2$ (mmHg), median (IQR)	42 (30–53)	46 (26–60)	38 (33–45)	0.203
Any signs of life prior to ED, *n* (%)	69 (43%)	41 (36%)	28 (64%)	0.001
Adrenaline dose (mg), median (IQR)	4 (2–6)	5 (3–7)	1 (1–4)	0.001
Amiodarone dose (mg), median (IQR)	300 (300–300)	300 (300–375)	300 (263–338)	0.29
ETT used at OHCA scene, *n* (%)	50 (31%)	41 (36%)	9 (21%)	<0.001
Laryngeal mask used at OHCA scene, *n* (%)	85 (54%)	69 (60%)	16 (36%)	<0.001
No ROSC before ED, *n* (%)	75 (47%)	71 (62%)	4 (9%)	<0.001
ROSC occurring before 15 min of EMS CPR, *n* (%)	40	16 (14%)	24 (55%)	<0.001
ROSC occurring before 20 min of EMS CPR, *n* (%)	46	19 (17%)	27 (61%)	<0.001
Time to pre-hospital ROSC (min), median (IQR)	17 (5–35)	26 (14–38)	7 (4–16)	<0.001
Arrest time points				
Arrest to patient contact (min), median (IQR)	11 (9–15)	11 (9–15)	12 (7–18)	0.796
Time on scene (min), median (IQR)	33 (24–44)	35 (27–45)	30 (20–43)	0.083
Arrest to hospital time (min), median (IQR)	56 (43–70)	60 (46–72)	48 (39–65)	0.027

P-value is controls *versus* T2DM; () is IQR for medians or 1 SD for means. CPR, cardiopulmonary resuscitation; $ETCO_2$, end-tidal carbon dioxide; IQR, interquartile range; OHCA, out-of-hospital cardiac arrests; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; SD, standard deviation.

in 61% ($n = 27$) survivors and 17% ($n = 19$) of non-survivors.

The median time spent at scene of resuscitation was 33 min (IQR 24–44), survivors 30 min (20–43) *versus* 35 min (27–45); non-survivors $P = 0.083$. Survivors had a higher percentage of witnessed (93%), shockable rhythm (89%) arrests. Seventy-nine (53%) patients had mechanical CPR (MCPR) during transfer, scene time did not vary between MCPR used; 33 min (IQR 24–45) or not used 32 min (IQR 24–44); $P = 1.000$.

Initial $ETCO_2$ in the ED was not significantly different by survivor status (non-survivors 35 mmHg [IQR 19–50] *vs* survivors 36 mmHg [IQR 33–45]; $P = 0.215$). Three patients had an $ETCO_2$ <10 mmHg and 15 patients had $ETCO_2$ <20 mmHg on arrival to the ED none of whom survived. Eighteen patients (8%) met ECPR inclusion criteria, 10 of which went on to receive ECPR, one of these patients survived. Six patients received ECPR outside defined inclusion criteria which included the sole ECPR survivor. Of the eight patients who met criteria but did not receive ECPR, three patients were out of the hours when ECPR was offered, three were at a hospital that did not offer ECPR and the remainder ROSC occurred while pending ECPR cannulation.

Twenty-three survivors (52%) underwent coronary angiography with 17 of these (74%) receiving coronary stenting.

Discussion

Our study provides important prospective data on OHCA to inform subsequent interventional trials. First, we found that the median on-scene resuscitation time by paramedics was consistent between survivors and non-survivors and whether MCPR was used or not. Although early transfer to hospital is essential for patients who may benefit from hospital-based interventions (such as angiography or ECMO), too earlier transfer from scene maybe associated with worse outcomes,[4] possibly due to compromising effective CPR during transportation. Hence, more research is needed on which patients would benefit from expedited transfer to hospital *versus* continued on-scene high-performance CPR and the optimal transfer timepoint.

Only 8% of patients in our study were found to be eligible for ECPR as per our inclusion criteria,[5] a finding consistent with other studies.[4] Survival in these refractory OHCA patients is markedly improved in highly developed emergency networks that can provide ECPR within 1 h of arrest. There is increasing evidence[6] that this may become the benchmark for delivery of care to these patients and has been shown to be cost effective, on an individual patient basis.[7] The best model of care to serve the maximal number of potential ECPR patients, needs to be tested, determined and costed at a system level.

$ETCO_2$ is a marker of the adequacy of conventional CPR and a $ETCO_2$ of <10 mmHg after 20 min resuscitation is shown to be associated with very poor outcomes. Our study supports these findings; however, median $ETCO_2$ did not differ between survivors and non-survivors. A $ETCO_2$ cut off to terminate resuscitation (e.g. <10 mmHg) or as an arbiter of subsequent intervention is attractive but needs larger prospective study validation.

The use of MCPR did not reduce median on-scene time. This may be due to several factors, including but not limited to: challenging on-scene dynamics, a learning curve and familiarity of MCPR for paramedics (MCPR was being rolled out in New South Wales during the study period) and a time delay in waiting for the arrival of the MCPR devices.

Study limitations

We included only OHCA transferred to participating hospitals. It is possible that more cardiac arrests were declared life extinct on scene who may have met ECPR criteria but were not transported to hospital. The limited numbers limit inferences able to be made but do provide for pilot data for subsequent studies. During the present study, MCPR devices was not widely available to paramedics, this has subsequently changed, therefore scene times may change. The study was undertaken during COVID-19 pandemic, timepoints may differ outside the pandemic period.

Conclusion

On-scene treatment times did not differ on survivorship. A small number of patients were ECPR eligible. A very low $ETCO_2$ on hospital arrival maybe a useful tool in prognostication and exclusion of patients for more advanced therapies. Our study provides pilot data to inform future cardiac arrest studies in Australia and will provide comparative data for such studies.

Acknowledgements

MD is supported by a Post-Doctoral Scholarship (Ref: 105849) from the National Heart Foundation of Australia. The National Heart Foundation had no role in the study design, collection, analysis or interpretation of the data nor in writing of the data and submission of the article. Open access publishing facilitated by The University of Sydney, as part of the Wiley - The University of Sydney agreement via the Council of Australian University Librarians. The members of the RESET Study Group are as follows: Brian Burns, MBBCh, MSc (Sydney Medical School, The University of Sydney, Sydney, Australia; New South Wales Ambulance, Sydney, Australia); Sophie Dyson, BA (Mathematics), BParamedicine (New South Wales Ambulance, Sydney, Australia); Danielle Austin, MBBS, PGClinEpi (Department of Intensive Care, Liverpool Hospital, Sydney, Australia); Jessica Arnold, BParamedicine (New South Wales Ambulance, Sydney, Australia); Saartje Berendsen, BHSc Med (Department of Emergency Medicine, Royal Prince Alfred Hospital, Sydney, Australia); Andrew Coggins, MBChB, MAcadMEd (Sydney Medical School, The University of Sydney, Sydney, Australia; Department of Emergency Medicine, Westmead Hospital, Sydney, Australia); Stuart Duffin, BMedSci, MBBS (Department of Intensive Care, Royal Prince Alfred Hospital, Sydney, Australia); Nicholas Dutton, MParamedSc, GradDipEmergHlth (MICA), BEd (New South

Wales Ambulance, Sydney, Australia); Rochelle Facer, MBBS (Department of Emergency Medicine, Concord Repatriation Hospital, Sydney, Australia); Ian Ferguson, MBChB, MCRP (UK) (Department of Emergency Medicine, Liverpool Hospital, Sydney, Australia); Paul Forrest, MBChB (Sydney Medical School, The University of Sydney, Sydney, Australia; Department of Anaesthesia, Royal Prince Alfred Hospital, Sydney, Australia); Julie Gawthorne, BN, MN (Department of Emergency Medicine, St Vincent's Hospital, Sydney, Australia; Nursing Research Institute, St Vincent's Health Network, Sydney, Australia); Natalie Kruit, MBBS (Hons), BA, BN (Department of Anaesthesia, Westmead Hospital, Sydney, Australia); James Mallows, MBBS Med (Department of Emergency Medicine, Nepean Hospital, Sydney, Australia); Kevin Maruno, BMedSci (Hons), MBBS (Department of Emergency Medicine, St Vincent's Hospital, Sydney, Australia); Peter McCanny, MBChB (Department of Intensive Care, Liverpool Hospital, Sydney, Australia); Sally Newman, BN (Department of Intensive Care, St Vincent's Hospital, Sydney, Australia); Matthew Oliver, BSc, MBBS, MSc (Sydney Medical School, The University of Sydney, Sydney, Australia; Department of Emergency Medicine, Royal Prince Alfred Hospital, Sydney, Australia); Claire Reynolds, MClin, BSc (Hons) (Department of Intensive Care, St Vincent's Hospital, Sydney, Australia); Richard J Totaro, MBBS (Department of Intensive Care, Royal Prince Alfred Hospital, Sydney, Australia); Timothy James Southwood, MBBS, MSc (Department of Intensive Care, Royal Prince Alfred Hospital, Sydney, Australia); Hergen Buscher, DEAA, EDIC (Department of Intensive Care, St Vincent's Hospital, Sydney, Australia); Mark Dennis, MBBS (Hons), PhD (Sydney Medical School, The University of Sydney, Sydney, Australia; Department of Cardiology, Royal Prince Alfred Hospital, Sydney, Australia); David Gattas (Department of Intensive Care, Royal Prince Alfred Hospital, The University of Sydney, Sydney, Australia).

Competing interests

None declared.

Data availability statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

References

1. Nagao K, Nonogi H, Yonemoto N *et al*. Duration of prehospital resuscitation efforts after out-of-hospital cardiac arrest. *Circulation* 2016; **133**: 1386–96.
2. Grunau B, Kime N, Leroux B *et al*. Association of intra-arrest transport vs continued on-scene resuscitation with survival to hospital discharge among patients with out-of-hospital cardiac arrest. *JAMA* 2020; **324**: 1058–67.
3. Gomersall CD, Joynt GM, Morley AP. End-tidal carbon dioxide and outcome of out-of-hospital cardiac arrest. *N. Engl. J. Med.* 1997; **337**: 1694.
4. Reynolds JC, Grunau BE, Elmer J *et al*. Prevalence, natural history, and time-dependent outcomes of a multicenter north American cohort of out-of-hospital cardiac arrest extracorporeal CPR candidates. *Resuscitation* 2017; **117**: 24–31.
5. Dennis M, Buscher H, Gattas D *et al*. Prospective observational study of mechanical cardiopulmonary resuscitation, extracorporeal membrane oxygenation and early reperfusion for refractory cardiac arrest in Sydney: the 2CHEER study. *Crit. Care Resusc.* 2020; **22**: 26–34.
6. Yannopoulos D, Bartos J, Raveendran G *et al*. Advanced reperfusion strategies for patients with out-of-hospital cardiac arrest and refractory ventricular fibrillation (ARREST): a phase 2, single centre, open-label, randomised controlled trial. *Lancet* 2020; **396**: 1807–16.
7. Dennis M, Zmudzki F, Burns B *et al*. Cost effectiveness and quality of life analysis of extracorporeal cardiopulmonary resuscitation (ECPR) for refractory cardiac arrest. *Resuscitation* 2019; **139**: 49–56.