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Editorial

Resuscitation highlights in 2016

Introduction

The number and quality of manuscripts submitted to Resuscitation continues to rise and in 2016, for the first time, exceeded 1000. The editors have highlighted some of the key papers published in the Journal in 2016.

Epidemiology and outcome

The EuReCa ONE study documented over one month the incidence, process, and outcome for out-of-hospital cardiac arrest (OHCA) throughout Europe.[1] Data were included on 10,682 confirmed OHCAs from 248 regions in 27 countries, covering an estimated population of 174 million. The incidence of cardiopulmonary resuscitation (CPR) attempts ranged from 19.0 to 104.0 per 100,000 population per year. Overall, 662/6414 (10.3%) in all treated cases survived to 30 days or hospital discharge.

An analysis of the U.S. Kids' Inpatient Database documented 29,577 paediatric in-hospital cardiac arrests out of 38,035,077 hospitalisations during the period 1997–2012, resulting in an overall incidence of 0.78 cardiac arrests for every 1000 discharges and mortality of 46%.[2] The incidence of paediatric in-hospital cardiac arrest increased while the mortality decreased. The incidence of in-hospital cardiac arrest (IHCA) was higher in males, infants, black children, children from metropolitan regions and children from regions with lower household incomes.

In an analysis of a Korean nationwide OHCA registry, during 2008–2014, 511 OHCAs (73% judged to be of cardiac cause) occurred in schools, leading to an annual incidence of 5.72 per 1000 schools.[3] Most victims were unwitnessed adult visitors who had a non-shockable initial documented cardiac arrest rhythm, although most received bystander CPR. One third of the arrests occurred during sports activity or at a sports facility. One hundred patients (19.6%) survived to discharge, 66 (12.9%) with a good neurological outcome.

In a study from the Resuscitation Outcomes Consortium (ROC), among 14,690 OHCA victims treated between 2005–2007, women had lower rates of survival than men.[4] However, when survival was adjusted for Utstein predictors, survival was similar between genders except in younger women.

Rapid response systems

The importance of strategies to prevent patients deteriorating to cardiac arrest has again been emphasised in several publications in *Resuscitation* in 2016. The prevalence and significance of abnormal vital signs prior to IHCA in adults from the Get With the Guidelines®-Resuscitation registry was assessed.[5] For the nearly 8000 patients assessed, abnormal vital signs were present in most 1–4 h before IHCA, and hospital mortality increased with increasing number of pre-arrest abnormal vital signs as well as increased severity of vital sign derangements. However, the optimal frequency of observation to identify at risk ward patients is not known. In a randomised trial of varying frequency of observations and early warning score (EWS) there was no significant reduction in the proportion of clinical deterioration with monitoring frequencies of thrice versus twice a day among patients admitted with an initial EWS of 0–1.[6] It is also not known if using the trends of repeated observations may improve the accuracy of predicting deterioration and poor outcomes so Churpek and colleagues investigated the value of using vital sign trends over time in five hospitals over a five-year period.[7] A total of 269,999 patient admissions were included and vital sign trends increased the accuracy of models designed to detect critical illness on the wards, with implications for current and future development of early warning scores.

The impact of a standardised rapid response system (RRS) on reducing serious adverse events, hospital mortality and unexpected deaths was investigated for the whole of New South Wales, Australia.[8] Introduction of this 'between the flags' program was associated with a continued decrease in the overall cardiac arrest rates, deaths after cardiac arrest, hospital mortality and failure to rescue.

A systematic review of paediatric track and trigger systems (PTTS) for hospitalised children assessed their validity, calibration, and effect on important patient outcomes (death, cardiac and/or respiratory arrest, unplanned transfer to intensive/high dependency care, immediate/urgent request for review, rapid response system activation).[9] Thirty-three PTTS were identified from 55 studies and when PTTS were implemented as part of a RRS, there was an improvement in outcome, supporting the validity and clinical utility of PTTS scores. The high number of systems is a significant confounder and requires further research on thresholds and the reliability, accuracy and calibration of PTTS.

Patient information may be easily available that could be used instead of RRS calls to initiate end-of-life discussions. In a case-control study of pre-existing risk factors for in-hospital death among older patients requiring a RRS attendance, multiple indicators of chronic illness, cognitive impairment and frailty were significantly associated with high risk of death.[10] The investigators propose that these features beyond the evident orders for limi-

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tation of medical treatment should be used to signal the need to initiate end-of-life discussions that may prevent futile interventions.

Basic life support

Research published in 2016 emphasises the critical importance that the emergency medical service call handler/dispatcher plays in orchestrating an effective community and emergency service response to cardiac arrest. The influence on outcome of time from call receipt to dispatch of EMS providers was examined in a retrospective observational study of 2678 patients with cardiac arrest treated by EMS from Seattle, WA.[11] The study found that shorter activation intervals were associated with improved survival to discharge (adjusted odds ratio (OR) for <1 min, 1.69 (95% CI 1.26–2.28); adjusted OR for 1–1.49 min, 1.54 (95% CI 1.14–2.08)) compared to response intervals of at least 1.5 min. A study of regional emergency medical communication centres in Norway documented variation in cardiac arrest recognition rates (78–94%) and instructions to start CPR (61–83%).[12] Qualitative evaluation found that agonal breathing continued to be the main barrier to cardiac arrest recognition. Different dispatch protocols, clinical experience and intuition influenced dispatchers' decision making. A retrospective review of emergency calls from the Save Hearts in Arizona Registry and Education (SHARE) Program identified practical barriers to initiating bystander CPR.[13] Inability to place the victim on a flat surface was the commonest barrier. In public locations, the caller not being with the patient was common. By contrast, in residential locations difficulty calming the caller, caller refusing CPR instructions and the caller leaving the telephone occurred commonly. What can be done to improve dispatcher process and outcomes? 'Measure, analyse, improve' is a mantra used in quality improvement literature. Implementing this approach alongside structured dispatcher training programmes can significantly improve bystander CPR rates with modest improvement in survival.[14] In this initiative, no difference was seen in community use of PAD—a finding observed elsewhere,[15] suggesting the need for further research in this area.[16]

High quality cardiopulmonary resuscitation

Push hard, push fast and keep going has been used as a teaching tool to remind CPR providers to maintain high quality CPR with minimal interruptions, yet some recent studies have produced conflicting findings on the importance of chest compression fraction. In a univariate analysis, compression fraction was associated with reduced survival (OR 0.07; 95% CI 0.01–0.36) whereas after adjustment for confounding variables, the OR for survival changed to 6.34 (95% CI 1.02–39.5), highlighting the importance of adjusting for confounding variables in CPR quality studies.[17] Technology advances continue to offer new ways to monitor and provide feedback on CPR quality with smart watches,[18] flexible pressure senses,[19] impedance signal monitoring[20] and automatic oesophageal intubation detectors[21] being added to the armamentarium of devices. Debriefing teams after cardiac arrest continues to show most promise although it is likely to have a ceiling effect when CPR quality at baseline is high.[22,23] Interest in haemodynamic/physiological rather than performance driven feedback continues to grow with a systematic review[24] and propensity matched cohort study[25] suggesting promise and highlighting the need for more research.

Defibrillation

There continues to be a considerable interest in double sequential defibrillation (DSD) for patients with recurrent/refractory ventricular fibrillation. An analysis of a large, urban, U.S. fire-based EMS system during 2013–15 documented 279 cases in which at least four conventional 200 J shocks had been given and not converted to a stable perfusing rhythm; 50 of these were empirically treated with dual defibrillation and 229 were given additional single 200 J shocks.[26] Neurologically intact survival was similar in the dual defibrillation (6%) and standard defibrillation (11.4%) groups ($p = 0.317$; OR 0.50; 95% CI 0.15–1.72). In another study, DSD was attempted in 12 patients who remained in VF after 5 single shocks—ROSC was achieved in three of these cases, all of whom survived to discharge.[27]

A novel method that uses the electrocardiogram (ECG) and thoracic impedance (TI) signals to detect return of circulation (ROSC) was evaluated using a database of signals captured by paramedic defibrillators in 385 OHCA patients.[28] A training subset was used to develop the method, and then applied to a test subset of the data. The method was 90.3% sensitive and 91.9% specific for detecting ROSC in the test set. Most importantly, the method detected ROSC virtually instantly for patients in whom it occurred compared to paramedics whose detection of ROSC occurred a median of 57 s later.

Advanced life support

Airways

Current evidence and guidelines suggest the use of a stepwise approach to airway management during CPR that is based on patient factors, and the skills of the rescuer.[29,30] If an advanced airway is used during CPR, the choice between supraglottic airways (SGAs) and tracheal intubation is uncertain. Two large randomised controlled trials (RCTs) will help answer the question of which advanced airway technique is best during CPR. The AIRWAYS-2 trial [ISRCTN: 08256118] assesses if the clinical effectiveness of the i-gel, a second-generation SGA, is superior to tracheal intubation during CPR in adult patients with OHCA.[31] In this UK study, paramedics are randomised to use either the i-gel or tracheal intubation as the first advanced airway intervention during CPR. The primary outcome is the modified Rankin Scale score at hospital discharge. This study is currently enrolling and aims to enrol 9070 patients. In North America, the Resuscitation Outcomes Consortium Pragmatic Airway Resuscitation Trial (PART) [NCT: 02419573] aims to recruit 3000 patients to compare the effectiveness of tracheal intubation (ETI) and laryngeal tube (LT) insertion on 72-h survival in adult OHCA.[32]

A systematic review of tracheal intubation identified 13 studies, with 1462 learners attempting to intubate the trachea of 19,108 patients.[33] It suggests that learners should complete at least 50 tracheal intubations to achieve at least a 90% elective tracheal intubation success rate with less than two attempts. The authors suggest that more training is likely to be required for emergency tracheal intubation where difficult intubation is far more common. The use of video laryngoscopes to improve intubation success is increasing despite the lack of RCTs. A recent RCT of tracheal intubation during CPR comparing direct laryngoscopy (DL) with video laryngoscopy (VL) with a Glidescope by intubators who had more than 50 previous successful tracheal intubations showed no difference in tracheal intubation success and speed, but did show a shorter pause in chest compression with VL.[34] An improvement in success rates with video laryngoscopy may only be limited to those

patients with a difficult intubation—this would require a far larger study.

Waveform capnography monitoring during CPR

Waveform capnography to confirm tracheal tube position in all patients who are intubated during CPR is now widely accepted and part of current guidelines.[29] The precise usefulness of measured end-tidal carbon dioxide ($ETCO_2$) values to guide resuscitation attempts remains uncertain however. An observational study of 178 cases of $ETCO_2$ values during CPR showed that the $ETCO_2$ value immediately after ROSC was higher compared to the value before ROSC (median $ETCO_2$ was 32 mmHg and 41 mmHg respectively, $p = 0.033$).[35] Patients with an increase in $ETCO_2$ of at least 10 mmHg during CPR were very likely to achieve ROSC, but ROSC could take several minutes to occur after the initial $ETCO_2$ rise.[36] Indeed most patients achieved ROSC without any significant increase in $ETCO_2$. Observational data from the American Heart Association's Get With The Guidelines-Resuscitation (AHA GWTG-R) Registry of 803 cases of IHCA showed an $ETCO_2 > 10$ mmHg during CPR was associated with improved survival to hospital discharge (OR 2.41, 95% CI 1.35–4.30, $p = 0.003$), and survival with favourable neurological outcome (OR 2.31, 95% CI 1.31–4.09, $p = 0.004$) compared to an $ETCO_2 \leq 10$ mmHg.[25]

Drugs during CPR

The evidence for any drug therapy during CPR remains uncertain. Much of our evidence comes from observational studies, and the efficacy of the drugs is often time dependent, and most likely impacted upon by other unmeasured confounders. For example, in a large RCT of amiodarone during CPR, early placebo was associated with a better outcome than later placebo.[37]

Adrenaline

Adrenaline can improve the rate of ROSC during CPR, but its effect on longer-term outcomes is uncertain.[30] In an assessment of the effect of 56 adrenaline doses of 1 mg in 36 patients during CPR, adrenaline produced only a small and clinically insignificant increase in cerebral oxygenation (rSO_2).[38] Our understanding of the effects of adrenaline on cerebral perfusion remain limited. A large UK RCT of adrenaline and placebo for OHCA has started (PARAMEDIC 2 [ISRCTN73485024]) with an aim of recruiting 8000 patients. PARAMEDIC-2 is a pragmatic, individually randomised, double blind, controlled trial and economic evaluation with a primary outcome of 30-day survival in OHCA patients.[39]

Antiarrhythmic drugs during CPR

The Resuscitation Outcomes Consortium–Amiodarone, Lidocaine or Placebo Study (ROC–ALPS) study showed no difference in survival to hospital discharge between amiodarone, lidocaine and placebo when given to patients with OHCA due to initial shock-refractory VF/pVT.[40] In this study the first dose of the trial drugs was given a mean (±SD) of 19.3 ± 7.4 min after the initial call and after a median of three shocks (interquartile range (IQR), 2–4) had been given. Furthermore, patients receiving amiodarone and lidocaine required fewer shocks for VF/pVT termination than those receiving placebo, had higher rates of hospital admission, and lesser need for CPR or antiarrhythmic therapies in hospital. A meta-analysis that included the ROC ALPS study identified seven studies for inclusion (three RCTs, four non-RCTs) and concluded that amiodarone and lidocaine equally improve survival at hospital admission in comparison with placebo. However, neither amiodarone nor lidocaine improve long-term outcome.[41] A Japanese observational study found no difference between nifekalant (n = 608) and amiodarone (n = 2353) on in-hospital mortality for OHCA patients with persistent VF on hospital arrival (81.5% versus 82.1%, respectively; difference, −0.6%; 95% CI, −5.2 to 4.1).[42] Giving an anti-arrhythmic drug relatively late in a resuscitation attempt is unlikely to improve outcome; there is evidence that early administration is associated with higher survival rates.[43]

Mechanical devices

A propensity-matched analysis of observational data from Utah re-enforces the International Liaison Committee on Resuscitation's (ILCOR) recommendation against the routine use of mechanical CPR in OHCA.[44] Researchers found reduced functional survival in patients receiving CPR via mechanical chest compression devices (relative risk of functional survival 0.41; 95% CI 0.24–0.7). By contrast, a systematic review and meta-analysis of eight studies which evaluated mechanical CPR use in hospital found improved hospital/30 day survival (odds ratio 2.34 (95% CI 1.42–3.85)).[45] Caution is advised when the patient is in a shockable rhythm because attempted defibrillation during mechanical chest compression results in lower termination of fibrillation rates than pausing the device to deliver a shock.[46]

Extracorporeal CPR (ECPR)

Current guidelines based on limited studies include consideration of the use of extracorporeal CPR (ECPR) in specific circumstances.[29] A recent survey identified 36 US centres that had undertaken emergency department ECPR.[47] A systematic review of ECPR for refractory OHCA of cardiac origin identified one guideline and twenty outcome studies.[48] The reported survival to discharge for ECPR was 22% and 13% with good neurological recovery. Additionally, 88 potential and 17 actual deceased organ donors were identified from non-survivors based on eight of the studies. Another meta-analysis identified 10 studies, and did not show superiority of ECPR for OHCA, but did suggest improvement in good neurological survival at 3–6 months after arrest.[49] Our knowledge about the role of ECPR is hampered by the lack of RCTs and publication bias in observational studies.

Drowning

A review of the Extracorporeal Life Support Organization (ELSO) registry identified 247 patients who received extracorporeal life support (ECLS) following a drowning event between 1986 and 2015.[50] Overall survival was 51.4%; 71.4% in patients without cardiac arrest (n = 84), 57.0% in patients requiring CPR and with ROSC prior to ECLS (n = 86), and 23.4% with ECPR (n = 77). A limitation of this registry study was that it did not include specific data about the actual drowning event. A systematic review and meta-analysis identified 24 cohort studies showing that a favourable outcome was associated with shorter compared to longer submersion durations in all time cut-offs evaluated: ≤5–6 min: risk ratio [RR] = 2.90 (95% CI 1.73, 4.86); ≤10–11 min: RR = 5.11 (95% CI 2.03, 12.82); ≤15–25 min: RR = 26.92 (95% CI 5.06, 143.3) and favourable outcomes were seen with shorter EMS response times (RR = 2.84; 95% CI 1.08, 7.47).[51] Submersion durations of greater than 25 min were invariably fatal.

Paediatric resuscitation

A study from the USA demonstrated using a novel high-risk clinical indicators checklist is feasible and provides timely and accurate identification of paediatric intensive care unit (ICU) patients at risk for cardiac arrest or code bell activation.[52] Video recorded

resuscitations of term and preterm newborns demonstrated significant total time without ventilation and identified reducing the time without ventilation during intubation may be achievable with better team coordination.[53] The role of tracheal suction in term non-vigorous meconium-stained neonates is controversial, so a pilot study was undertaken to evaluate the effect of 'no endotracheal suction' on occurrence of meconium aspiration syndrome (MAS) and/or all-cause mortality in non-vigorous neonates born through meconium stained amniotic fluid.[54] By demonstrating similar outcomes in intubated and non-intubated groups the study shows that it is feasible to randomise infants to receive or not receive endotracheal suction. A multi-centre trial should address whether the current practices and guidelines are justified.

Trauma and hypothermia

Impact brain apnoea (IBA), the phenomenon of apnoea following traumatic brain injury (TBI), may be a significant and preventable contributor to deaths from trauma. First reported in 1705, it is characterised by cessation of spontaneous breathing following a TBI and is commonly accompanied by a catecholamine surge with hypertension followed by cardiovascular collapse. In a review of the topic, examples from clinicians attending head-injured patients within a few minutes of injury were described and potential for the study and intervention for IBA using advances in remote technology were discussed.[55]

Resuscitation reported the first use of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in the pre-hospital setting to control catastrophic haemorrhage.[56] Following a fall the patient suffered internal haemorrhage associated with a pelvic fracture. A REBOA balloon catheter was inserted at the scene to control likely fatal exsanguination. The patient survived to undergo emergency angio-embolisation and subsequent surgery with eventual full recovery.

Post-resuscitation care

Post-cardiac arrest syndrome

A marked systemic inflammatory response is a well-recognised feature of the post-cardiac arrest syndrome (PCAS) but the relationship of the severity of this inflammatory response to outcome has not been well quantified. Among a cohort of 102 patients, non-survivors and patients with poor functional outcome had significantly higher IL-1Ra, IL-6, IL-8, and IL-10 values (all $p < 0.001$) compared with survivors.[57] Baseline IL-6 values were a good predictor of mortality (area under the curve (AUC) = 0.83; 95% CI 0.75–0.92) and in multivariate analysis were strongly associated with mortality but not neurological outcome. In a sub-analysis of 682 patients in the Targeted Temperature Management (TTM) trial, high IL-6 values at day 1–3 were independently associated with severity of PCAS with no interaction of target temperature, and high IL-6 values were associated with increased mortality.[58]

Targeted temperature management

The ILCOR Advanced Life Support task force undertook a systematic review of TTM after cardiac arrest and published treatment recommendations that have been incorporated into regional guidelines.[59,60] The task force recommended TTM at a constant temperature between 32 °C and 36 °C for at least 24 h for adults with OHCA and an initial shockable rhythm. Similar suggestions were made for OHCA with a non-shockable rhythm and IHCA. Canadian guidelines on TTM have also been published and are broadly consistent with the ILCOR advisory statement.[61]

In an observational study from Korea, TTM was undertaken in 1703 (15.1%) of 11,256 patients admitted to hospital after OHCA.[62] The use of TTM was associated with good neurological outcome (23.5% versus 15.0%; adjusted OR 1.25; 95% CI 1.05–1.48) and the effect of TTM seemed to be greatest in witnessed OHCA patients with PEA as the initial rhythm. In a systematic review of nine studies that included 801 cardiac arrest survivors, TTM was not associated with long-term quality of life.[63]

Some authors have suggested that TTM at lower temperature may benefit particularly those patients with long no-flow times. However, in a sub-analysis of the TTM trial, TTM at 33 °C compared to 36 °C was not associated with an increased probability of a good neurological function for patients with longer no-flow times.[64] In a study of 1103 witnessed OHCA patients of whom 613 were cooled to 33 °C, TTM treatment was associated with favourable outcome among those with short to moderate low-flow times but not among those in the fourth quartile of low-flow time.[65] Investigators from Korea confirmed an association between time from collapse to ROSC among 930 adults who were treated with TTM after OHCA, but even among those with a collapse to ROSC time of >20 min, a good neurological outcome was achieved in 22.2% (150/526) of patients.[66]

Previous observational studies have indicated that OHCA patients with ROSC who cool spontaneously and have low temperatures on admission have increased mortality compared with those with higher temperatures on admission to hospital. However, a sub-analysis of 939 patients in the TTM trial showed that the low temperature on arrival is associated with unfavourable circumstances during the resuscitation (particularly a prolonged time to ROSC) and does not seem to be related to mortality per se.[67]

Studies documenting the impact on coagulation of mild induced hypothermia have produced varying results. Thromboelastography is one of the most sensitive methods for evaluating coagulation and, in a study of 22 OHCA patients treated with TTM at a target temperature of 33 °C, it was used to compare clotting during hypothermia and normothermia; no substantial difference in coagulation was found in hypothermia compared with normothermia.[68]

Haemodynamics

In a feasibility study of 20 post-cardiac arrest patients, cerebral autoregulation and the optimal mean arterial blood pressure (MAP_{OPT}) were evaluated using the dynamic relationship between MAP and regional oxygen saturation (rSO_2) using near infrared spectroscopy (NIRS).[69] The mean overall MAP and MAP_{OPT} were 76 mmHg (SD 10) and 76 mmHg (SD 7), respectively.

Oxygen

Observational studies evaluating the association of hyperoxia with mortality in post-cardiac arrest patients have produced conflicting results and prospective, randomised trials are awaited. In a retrospective, nested cohort study, the introduction of conservative oxygen therapy (target SpO_2 88–92%) for 50 post-cardiac arrest patients admitted to ICU was compared with an historical control group of the same size.[70] Compared with the conventional group, conservative group patients had significantly lower PaO_2 values and FiO_2 exposure ($p < 0.001$, respectively). More conservative group patients were classified as normoxaemic and fewer as hyperoxaemic. This study indicates the feasibility and physiological safety of conservative oxygen therapy in patients admitted to ICU after cardiac arrest.

Targeted therapeutic mild hypercapnia

Observational studies in post-cardiac arrest patients have documented an association between mild hypercapnia and improved neurological outcome. In a phase II safety and feasibility multicentre, randomised controlled trial (RCT), post-cardiac arrest patients were allocated to 24 h of targeted normocapnia (TN) ($PaCO_2$ 35–45 mmHg) or targeted therapeutic mild hypercapnia (TTMH) ($PaCO_2$ 50–55 mmHg). The increase in serum neuron specific enolase (NSE) values (the primary end point) were significantly more pronounced in the TN group (P = 0.04).[71] This study has shown that TTMH is feasible and a large-scale RCT is planned. In a study of seven post-cardiac arrest patients, in comparison with normocapnia, mild hypercapnia increased rSO_2 as assessed by NIRS.[72]

Coronary revascularisation

Whether post-OHCA patients with ROSC but without ST-elevation on their ECG should be taken for urgent cardiac catheterisation remains unclear. A systematic review and meta-analysis of 11 papers showed that when taken to the catheterisation laboratory a third of patients without ST-elevation had an acute culprit lesion requiring intervention, compared with two-thirds of patients with STEMI; OR 0.15 (95% CI 0.06–0.34).[73]

Prognostication

In a study of 373 adult cardiac arrest patients treated with TTM, continuous EEG monitoring showing an unreactive background and status epilepticus were predictive of a poor functional outcome and in-hospital mortality.[74] In another study, ultrasound was used to measure optic nerve sheath diameter (ONSD) as an indicator of brain oedema at various intervals in 36 post-arrest patients.[75] ONSD correlated significantly with brain oedema assessed by the cerebral grey to white matter attenuation ratio (GWR) on CT scan and was associated with in-hospital mortality and CPC score. In a similar study involving a cohort of 119 post-cardiac arrest patients in Korea, a combination of ONSD and GWR provided better prognostic performance than either modality alone.[76]

It is generally accepted that withdrawal of life-sustaining therapy because of poor neurological prognosis (WLST-N) decisions have often been made prematurely in comatose post-cardiac arrest patients. In a secondary analysis of the ROC PRIMED study, investigators have used propensity score modelling to evaluate the potential impact of early WLST decisions, defined as those made before 72 h post-cardiac arrest.[77] Of 16,875 subjects treated by EMS in the ROC PRIMED study, 4265 (25%) arrived at hospital and survived for at least 1 h—these formed the study group. Adjusted analyses predicted that subjects in whom WLST-N occurred before 72 h would have 26% survival and 16% functionally favourable survival if WLST-N before 72 h did not occur. The investigators estimated that if these data were extrapolated nationally, WLST-N before 72 h might be associated with mortality in approximately 2300 Americans each year, of whom nearly 1500 (64%) might have had a good functional recovery (mRS $\leq$ 3).

Cardiac arrest centres

In an analysis of 2238 patients treated in Vienna, Austria, favourable outcome was achieved in 267 patients (31%) and survivors were more likely to be treated in a high frequency (>100 admissions/year) centre (OR 1.6; 95% CI 1.2–2.1; p = 0.001).[78] In an adjusted analysis of post-cardiac arrest patients admitted to seven medical centres in Southwestern Pennsylvania during 2005–2013, treatment at the one high-volume cardiac arrest centre was associated with improved survival compared to treatment at the other centres (hazard ratio 1.49, 95% CI 1.19–1.86).[79]

Education and quality improvement

The European Resuscitation Council (ERC) Kids Save Lives saw refreshed focus and enthusiasm with the publication of a position statement summarising 10 key principles on how to increase survival through kids saving lives.[80] Recognising that up to 70% of OHCA are witnessed by family members, friends and other bystanders, and that mandatory nationwide training of school children has the highest impact for improving bystander CPR rates, this is a logical area for training investment. Evaluation of this initiative found that 81% of European countries are aware of Kids Save Lives; 19% had legislation in place which mandated CPR in schools training and 62% were considering such legislation.[81] Seventeen countries participated in the European Restart a Heart Day. Together this represents great progress for improving the training of CPR skills in our community whilst highlighting the potential for us to do even better.

The World Health Organization endorsed the "Kids Save Lives" Statement in 2015. This joint statement from the ERC, the European Patient Safety Foundation, ILCOR and the World Federation of Societies of Anesthesiologists (WFSA) recommends two hours of CPR training annually from the age of 12 years in all schools worldwide. Healthcare professionals, teachers trained to teach CPR and others can successfully teach school children, and all can serve as multipliers. Trained teachers can provide adequate resuscitation training in schools.[82] CPR knowledge and skills can be spread further by asking children to teach their family and friends. Multi-modal training is encouraged and a recent study demonstrated brief CPR video training can result in improved CPR quality and responsiveness in high school students. Brief educational interventions were beneficial to improve CPR responsiveness but psychomotor training was important for CPR quality.[83]

Conflict of interest statement

J.P.N. is Editor-in-Chief of Resuscitation and Chair of the European Resuscitation Council. He is a co-investigator for two National Institute of Health Research (NIHR) funded studies: AIRWAYS-2 and PARAMEDIC-2.

J.P.O., M.J.A.P., G.D.P. and J.S. are Editors of Resuscitation.

J.P.O. serves as Cardiac Co-Chair for the National Institutes of Health-sponsored Resuscitation Outcomes Consortium (ROC). He serves as the Virginia Commonwealth University Principal Investigator for the National Institutes of Health-sponsored Neurological Emergency Treatment Trials Network (NETT).

G.D.P. is Co-Chair of the International Liaison Committee on Resuscitation. He is Chief Investigator for the NIHR funded PARAMEDIC-2 trial.

J.S. is Chair of the Advanced Life Support Task Force of the International Liaison Committee on Resuscitation.

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J.P. Nolan [a,b,*]
[a] *School of Clinical Sciences, University of Bristol, UK*
[b] *Anaesthesia and Intensive Care Medicine, Royal United Hospital, Bath, UK*

J.P. Ornato
Department of Emergency Medicine, Virginia Commonwealth University Health System, Richmond, VA, USA

M.J.A. Parr [a,b]
[a] *Director of Intensive Care, Liverpool and Macquarie University Hospitals, Australia*
[b] *University of New South Wales and Macquarie University, Sydney, Australia*

G.D. Perkins
Critical Care Medicine, University of Warwick, Warwick Medical School and Heart of England NHS Foundation Trust, Coventry, CV4 7AL, UK

J. Soar
Anaesthesia and Intensive Care Medicine Southmead Hospital North Bristol NHS Trust, Bristol, BS10 5NB, UK

* Corresponding author at: School of Clinical Sciences, University of Bristol, UK.
E-mail addresses: jerry.nolan@nhs.net (J.P. Nolan), ornato@aol.com (J.P. Ornato), m.parr@unsw.edu.au (M.J.A. Parr), g.d.perkins@warwick.ac.uk (G.D. Perkins), jasmeet.soar@nbt.nhs.uk (J. Soar).

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