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Editorial

Resuscitation highlights in 2014

The number and quality of manuscripts submitted to *Resuscitation* continues to rise. The editors have highlighted some of the key papers published in the Journal in 2014.

1. Epidemiology

In 2014, a team of international investigators produced a landmark paper that updated the Utstein resuscitation registry templates for out-of-hospital cardiac arrest.[1] The primary template emphasises reporting of bystander-witnessed cardiac arrests with initial shockable rhythm as the most important measure of EMS system efficacy and all EMS system-treated arrests as a measure of system effectiveness.

More countries are now tracking both incidence and outcome from both in-and out-of-hospital cardiac arrest. One of the newest is the United Kingdom National Cardiac Arrest Audit (NCAA), whose investigators recently reported on 22,628 hospitalised patients aged 16 years or over receiving chest compressions and/or defibrillation and attended by a hospital-based resuscitation team in 144 acute care hospitals.[2] Adult cardiac arrests occurred with an overall median incidence of 1.5 events per 1000 hospital admissions. An initial shockable rhythm was present in 17% of cases. Overall survival to hospital discharge was 18.4%, but varied substantially across hospitals.

Investigators from Melbourne, Australia, characterised the causes and outcomes of respiratory arrests occurring in a Metropolitan tertiary teaching hospital.[3] Respiratory arrests occurred at a rate of 0.5 per 1000 inpatient admissions. An elevated respiratory rate and/or progressive hypoxaemia preceded the event in 39% of cases. In-hospital survival was 75% for respiratory arrests compared to only 25% for cardiac arrests.

In Perth, Western Australia, St. John ambulance paramedics attended 12,421 out-of-hospital cardiac arrests of presumed cardiac ideology during the last 14 years.[4] During the study period, there was a statistically significant decline in the age-and-sex-standardised cardiac arrest incident rate. Investigators attributed this favourable change to improvements in cardiovascular risk profiles.

In Melbourne, Australia, investigators analysed data from 38,378 out-of-hospital cardiac arrests attended by emergency medical services (EMS) personnel in which the initial rhythm was non-shockable.[5] The initial rhythm was asystole in 88% and pulseless electrical activity (PEA) in 12% of cases. Survival to hospital discharge was 1.1% for asystole and 5.9% for PEA. Survival outcomes did not improve over the 10-year study period from 2003 to 2013.

In Osaka, Japan, researchers studied the outcome of elderly out-of-hospital cardiac arrest victims.[6] One-month survival with neurologically favourable outcome, improved from 1.4% in 1999 to 4.8% in 2011 ($p < 0.001$). The proportion of nursing home patients with a neurologically favourable outcome did not change during this period. However, in a separate study, Danish investigators showed that nursing home residents admitted to hospital after cardiac arrest have survival rates that are similar to non-nursing home patients after adjusting for known prognostic factors in pre-existing comorbidities.[7]

An increasing number of epidemiological studies are now focusing on paediatric cardiac arrest. Investigators from Little Rock, Arkansas, analysed data on 329,982 patients from 108 centres in the United States participating in a virtual paediatric intensive care unit (ICU) system.[8] Cardiac arrest occurred in 2.2% of patients with an associated mortality rate of 35%. Both the incidence and mortality of cardiac arrest varied substantially across hospitals. Using multivariate models controlling for patient and centre characteristics, centre volume was not associated with either incidence or mortality from cardiac arrest.

In a separate study, investigators from Osaka University used a nationwide, prospective, population-based observational database to look at the relationship between survival following paediatric out-of-hospital cardiac arrest and time of day or day of week and 3278, bystander-witnessed cases.[9] One-month survival rate was significantly lower during nights and weekends/holidays, even when adjusted for potentially confounding factors.

2. Rapid response systems

In 2014, *Resuscitation* further consolidated its position as the lead journal for clinical publications related to rapid response systems (RRS) for the prevention of cardiac arrest. With the introduction of the National Early Warning Score (NEWS) across the United Kingdom (UK), a UK-based group was concerned that its specificity in patients with chronic hypoxaemia could lead to over triggering and alarm fatigue.[10] They designed a variation of NEWS for patients with chronic hypoxaemia: a Chronic Respiratory Early Warning Score (CREWS) and found that it could reduce excessive triggers and alarm fatigue, whilst identifying appropriate patients in need of response.

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The performance of human-generated NEWS was compared with one generated from algorithms using decision tree analysis.[11] In this rapidly evolving area of prediction of deterioration they suggested that a decision-tree technique may be used to develop models for disease-specific Early Warning Scores (EWS) that may be useful in the future.

A United States (US)-based group of investigators undertook a comparative analysis of common EWSs to see how they would function in automated systems.[12] They suggested that the most widely used weighted track-and-trigger scores would not be good for use in an automated alarm system. As automated systems are probably the future of Rapid Response Systems this will be a key area for future research.

Chen and colleagues from Australia compared outcomes at a teaching hospital with a mature RRS, with three similar teaching hospitals without a RRS between 2002 and 2009.[13] The findings add to the weight of evidence that implementation of a RRS is associated with a significant reduction in the rate of inhospital cardiac arrest (IHCA), IHCA-related mortality and overall hospital mortality.

Petersen and colleagues from Denmark have looked at the performance of a new EWS system by reviewing all serious adverse events over a 6-month time period and found deficiencies in compliance, escalation and care provision.[14] They suggest that this quality information may be useful in improving compliance and performance of EWS systems.

3. Basic life support and CPR quality

A systematic review confirmed that both 'cardiac pump' and 'thoracic pump' have a key role in driving effective blood flow during adult cardiopulmonary resuscitation (CPR). The effect of each mechanism is highly depended on other resuscitation parameters, such as positive pressure ventilation and compression depth.[15] The integration of measurements of CPR quality with feedback technology allows CPR providers to improve performance[16–18] but a systematic review found no consistent evidence that this translates into improved patient outcomes.[18] One reason may be that CPR feedback systems differ in how they measure and provide feedback about CPR quality.[19] Transthoracic impedance signals can be used to produce reliable estimates of CPR quality indices[20,21] with the exception of chest compression depth.[22] Chest compression depth can be recorded by the use of an accelerometer device. However the accuracy of measurements is reduced with incomplete chest decompression[23] and when CPR is performed on a soft surface.[24] A new real-time compression depth feedback device that measures changes in magnetic field strength between a back pad and a chest pad was able to overcome the limitations of accelerometer technology independent of the stiffness of the surface[24] and improve the quality of simulated CPR.[25]

4. Defibrillation

Investigators in Canada studied data from 20,165 out-of-hospital cardiac arrest patients treated by EMS providers.[26] Good functional survival was associated with younger age, shorter times from collapse to initial defibrillation, and use of post-cardiac arrest targeted temperature management.

In Victoria, Australia, use of a public automated external defibrillator (AED) increased almost 11-fold between 2002 and 2013.[27] Investigators studied 2270 out-of-hospital cardiac arrest cases in which the event occurred in a public place. EMS personnel provided first defibrillation in 93.4% of cases. Bystanders using a public AED provided first defibrillation in 6.7% of cases. First defibrillation by a bystander using an AED was associated with a 62% increase in the odds of survival to hospital discharge.

A prospective, multicenter, international observational database from 12 European and Latin American countries was used to study the results of defibrillation during the treatment of 502 children with in-hospital cardiac arrest.[28] Ventricular fibrillation, or tachycardia was the first documented cardiac arrest rhythm in 43% of cases. Return of spontaneous circulation was obtained in 63% of all cases and was higher in those whose first documented cardiac arrest rhythm was ventricular fibrillation/tachycardia. Surprisingly, clinical outcome did not appear to be related to the cause or location of arrest, type of defibrillator/waveform, energy dose per shock, number of shocks, or cumulative energy dose. The authors concluded that the optimal paediatric defibrillation dose remains to be determined.

Lemkin et al. used six cadavers to estimate the rescuer-received dose of electrical energy when hands-on defibrillation was simulated.[29] Using this model, defibrillation exposed rescuers to energies between 1 and 8 J, which exceeds the accepted energy exposure levels. The authors concluded that hands-on defibrillation poses a significant risk to rescuers using currently available personal protective equipment and resuscitation procedures.

4.1. Trauma

Nevin and colleagues reviewed child trauma victims who required pre-hospital advanced airway management over a 12-year period and found their physician-led, pre-hospital trauma service attended 1933 children and there were 315 (16.3%) pre-hospital intubations. The majority received a rapid sequence induction and the main injury mechanism was road traffic crash and there was high success rate of advanced airway management.[30] Kleber and colleagues from Berlin looked at the epidemiology and autopsy data for failed trauma resuscitations over a 12-month period which led them to present an algorithm for use in trauma associated cardiac arrest situations.[31]

Schober and colleagues from Austria looked at outcomes for patients admitted to a Vienna University Hospital with cardiac arrest due to accidental hypothermia. While the condition appears to be rare the prognosis was particularly good for patients where hypothermic cardiac arrest was the result of intoxication.[32]

4.2. Drowning

Claesson and colleagues studied changes from 1990 to 2012 in characteristics and survival from cardiac arrest after drowning. Improved bystander help and CPR and early EMS arrival were credited for the improved survival found.[33] Quan and colleagues from the US failed to demonstrate any survival benefit from cold water drowning and that the estimated submersion duration was the best predictor of outcome. They suggested that resuscitation recommendations should be revised to reflect that after 10 min of submersion survival is highly unlikely.[34] Suominen and colleagues from Finland reported late cognitive and neurological outcome for surviving drowned children who had received CPR and found that 57% of the resuscitated children had neurological dysfunction. Clearly, neuropsychological long term follow-up in drowned children is highly recommended.[35] Szpilman and an international group have produced a Drowning Chain of Survival based on a best evidence approach and comprising of five links covering prevent drowning, recognise distress, provide flotation, remove from water, and provide care as needed.[36]

5. Advanced life support

5.1. Airway

A stepwise approach to airway management during CPR and after return of spontaneous circulation (ROSC) that is based on patient factors and the skills of the rescuer seems sensible as there is still little evidence to support any particular approach. A review of airway techniques used by paramedics in 196 resuscitation attempts during the REVIVE-airways study 'usual practice' arm showed the initial approach was bag-mask for 108 (55%), a supraglottic airway device (SAD) for 39 (20%) and tracheal intubation for 49 (25%). There were further airway interventions in 24% of tracheal intubation cases, 84% with bag-mask and 56% with a SAD.[37]

Data from 10,691 OHCA cases in the US CARES registry showed 5591 had tracheal intubation, 3110 SAD, and 1929 had no advanced airway.[38] Compared with SAD, tracheal intubation achieved better risk-adjusted outcomes with higher sustained ROSC (OR 1.35; 95%CI 1.19–1.54), hospital survival (1.41; 1.14–1.76) and hospital discharge with good neurologic outcome (1.44; 1.10–1.88). Survival was better for patients who received no advanced airway. Interpreting this observational data is challenging as choice of airway is complex and CARES is not specifically focused on airway interventions, so many confounders and complications related to airway interventions such as failed intubation are not measured. The 2012 National Emergency Medical Services Information System (NEMSIS) recorded almost 20 million Emergency Medical Services activations in the US that included 74,993 tracheal intubations, 21,990 alternate airways, and 1332 cricothyroidotomies.[39] Overall successful tracheal intubation rate was reported as 63,956/74,993 (85.3%; 95%CI 85.0–85.5) and broken down into: cardiac arrest 33,558/39,270 (85.5%), non-arrest medical 12,215/13,611 (89.7%), non-arrest injury (90.1%), children <10 years 2069/2468 (83.8%), and rapid sequence intubation 5265/5658 (93.1%). Alternative airways had an overall success of 79.6% (95%CI 79.1–80.2) broken down in order of popularity and insertion success as Combitube 79.0% (95%CI 78.2–79.9), King LT 89.7(95%CI 89.0–90.3), laryngeal mask airway (66.0: 64.3–67.7), and Esophageal-Obturator at 38.0% (95%CI 34.9–41.0). The NEMSIS data does not include second generation SADs such as the i-gel. A small single-centre, prospective 'open label' OHCA randomised controlled trial (RCT) compared the i-gel with the laryngeal mask.[40] In the 51 patients randomised, i-gel insertion success was higher (90% vs. 57%; $p = 0.02$). Data from the UK Airway Management in cardiac arrest patients (AIRWAYS-2) cluster randomised trial (UKCRN ID17761) comparing i-gel vs. tracheal intubation for initial OHCA airway management may shed further light on the best advanced airway during CPR.

5.2. Mechanical devices

Mechanical chest compression devices automate the process of chest compressions. In 2014, three multi-centre randomised trials evaluated mechanical chest compression devices (Autopulse[41], LUCAS[42,43]). The studies showed similar survival rates between mechanical and manual CPR. Analysis of injury patterns showed that rib fractures were more frequent after mechanical CPR but there was no difference in the incidence of sternal fractures. No injury was deemed fatal by the pathologist.[44]

5.3. Extracorporeal cardiopulmonary resuscitation (eCPR)

Extracorporeal CPR (eCPR) can increase the time window for achieving ROSC and identifying and treating a reversible underlying cause. The journal has published a large amount of observational data[45] showing that eCPR is feasible for both IHCA and OHCA in selected populations but little in the way of RCTs. The CHEER study (mechanical CPR, hypothermia, ECMO and early reperfusion) enrolled 26 patients with refractory cardiac arrest (15 IHCA, 11 OHCA).[46] It showed that mechanical CPR, rapid intravenous administration of 30 mL/kg of ice-cold saline to induce intra-arrest therapeutic hypothermia, percutaneous cannulation of the femoral artery and vein by critical care physicians and veno-arterial extra-corporeal membrane oxygenation (ECMO) was feasible with 14/26 (54%) survival do hospital discharge with good neurological outcome. Implementation of eCPR requires a well-drilled team that is available at short notice. Further information about the eCPR protocols used in the CHEER study is available at http://edecmo.org/evidence-ecls/protocols/ (accessed 3 January).

5.4. Vasopressors

The use of vasopressors during cardiac arrest remains a hot topic. We still do not know if adrenaline (epinephrine) during CPR is beneficial or harmful in terms of neurologically favourable survival. A systematic review of adrenaline for adult OHCA included 14 RCTs ($n = 12{,}246$):[47] one RCT compared standard-dose adrenaline (SDA) to placebo ($n = 534$), six compared SDA to high-dose adrenaline (HDA) ($n = 6174$), six compared SDA to an adrenaline/vasopressin combination ($n = 5202$), and one compared SDA to vasopressin ($n = 336$). There was no survival to discharge or neurological outcome differences for any comparison. SDA showed improved ROSC (RR 2.80, 95%CI 1.78–4.41, $p < 0.001$) and survival to admission (RR 1.95, 95%CI 1.34–2.84, $p < 0.001$) compared to placebo. SDA showed decreased ROSC (RR 0.85, 95%CI 0.75–0.97, $p = 0.02$; I2 = 48%) and survival to admission (RR 0.87, 95%CI 0.76–1.00, $p = 0.049$; I2 = 34%) compared to HDA. There were no differences in outcomes between SDA and vasopressin alone or in combination with adrenaline. Another systematic review of vasopressin studies identified 10 RCTs with a total of 6120 patients.[48] Vasopressin use during CPR had no beneficial impact compared with adrenaline for ROSC [OR 1.19, 95%CI 0.93, 1.52], survival to hospital discharge [OR 1.13, 95%CI 0.89, 1.43], and favourable neurological outcome [OR 1.02, 95%CI 0.75, 1.38]. The Prehospital Assessment of the Role of Adrenaline: Measuring the Effectiveness of Drug Administration in Cardiac Arrest (PARAMEDIC-2) RCT (ISRCTN 73485024) comparing adrenaline with placebo will hopefully provide some answers about the role of adrenaline during CPR.

Another issue that is commonly raised is that adrenaline dosing is not tailored to individual circumstances during CPR. Indeed little is known about the optimal timing and dosage for adrenaline use during CPR. Observational data from 20,909 IHCA events in the Get With The Guidelines-Resuscitation (GWTG-R) registry showed that compared with a reference period of 4–5 min survival to hospital discharge was higher with longer average dosing periods: 6 to <7 min/dose, adjusted odds ratio [OR], 1.41 (95%CI 1.12–1.78); 7 to <8 min/dose, adjusted OR, 1.30 (95%CI 1.02–1.65); 8 to <9 min/dose, adjusted OR, 1.79 (95%CI 1.38–2.32); 9 to <10 min/dose, adjusted OR, 2.17 (95%CI 1.62–2.92) for both shockable and non-shockable cardiac arrest rhythms.[49]

5.5. Monitoring, ultrasound, and goal-directed CPR

There is growing support for using technology to monitor more than the heart rhythm and clinical signs during CPR. Sutton and colleagues suggested greater use of coronary perfusion pressure (CPP) monitoring or diastolic blood pressure (DBP) during CPR, aiming for CPP > 20 mmHg when an arterial and central venous pressure (CVP) is available (CPP approximates to aortic end diastolic pressure – CVP), or a DBP > 25 mmHg when just an arterial pressure is available.[50] An easier option is to monitor end-tidal carbon dioxide ($ETCO_2$) during CPR. The list of uses of waveform capnography during CPR is growing from tracheal tube confirmation and ventilation rate to potentially include monitoring chest compression quality, identification of ROSC, and prognostication during CPR. A prospective observational study of OHCA recorded the initial $ETCO_2$ after advanced airway insertion in 271 cases and identified 22 patients with an initial $ETCO_2 \leq 1.3$ kPa (10 mmHg).[51] Four of these patients achieved ROSC suggesting we should not use $ETCO_2$ alone to prognosticate during CPR.

Ultrasound can be used by trained rescuers to identify and treat reversible causes during CPR although a systematic review revealed only few high quality studies that show improved outcomes with its use.[52] An interesting observation is that ultrasound can be used to detect mechanical cardiac activity in those who are clinically in cardiac arrest. Patients with 'pseudo' PEA have better outcomes than those with true PEA or asystole. Observations from six cases reported that cardiac ultrasound during CPR can be used to guide hand position to optimise chest compressions.[53]

6. Post-resuscitation care

6.1. Post-cardiac arrest syndrome

Previous studies have resulted in conflicting data relating to the cerebral blood in comatose cardiac arrest survivors. The cerebral haemodynamics of 54 post-cardiac arrest patients on an intensive care unit in Berlin were studied using duplex ultrasound.[54] Cerebral blood flow varied widely (201–1100 mL min^{-1}) and there was no correlation between cerebral blood flow or intracranial blood flow characteristics and outcome.

6.2. Targeted temperature management

A secondary analysis of the 16,875 subjects in the Resuscitation Outcomes Consortium (ROC) PRIMED trial showed that rates of early cardiac catheterisation (19.2%), coronary reperfusion (17.7%) and induced hypothermia (39.3%) were higher in hospitals treating more subjects per year.[55] Odds of survival increased with hospital volume (per 5 subjects per year OR 1.06; 95%CI 1.04–1.08). Survival was independently associated with early coronary angiography (OR 1.69; 95%CI 1.06–2.70), coronary reperfusion (OR 1.94; 95%CI 1.34–2.82), and induced hypothermia (OR 1.36; 95%CI 1.01–1.83).

Hypothermia impairs drug metabolism and is associated with reduced systemic clearance of cytochrome P450 metabolised drugs. Patients with cardiac arrest caused by acute coronary syndromes are typically treated with aspirin and a P2Y12 receptor inhibitor such as clopidogrel, prasugrel or ticagrelor. The platelet inhibitory effect of these drugs is likely to be influenced by mild hypothermia and was investigated in 164 patients, 84 of whom were treated with intravascular cooling to a target temperature of 33 °C.[56] Platelet reactivity index (PRI) was assessed using vasodilator-stimulated phosphoprotein (VASP) phosphorylation analysis. Platelet inhibition by these drugs was significantly impaired with hypothermia and this effect was most marked with clopidogrel compared with prasugrel and ticagrelor.

Although intravascular techniques for temperature control are thought to provide more precise temperature control than external techniques, many clinicians are concerned that the intravascular catheters may cause significant complications such as deep vein thrombosis. Among 61 patients treated with endovascular cooling, catheter related thrombosis was observed in 9 (14.7%) – these all occurred in patients who were receiving prophylaxis with unfractionated heparin; none occurred in those fully anticoagulated with unfractionated heparin.[57]

One of the postulated benefits of mild hypothermia in the treatment of the post-cardiac arrest syndrome (PCAS) is that it may reduce the inflammatory response that accompanies this condition. In a sub-analysis of the Targeted Temperature Management (TTM) trial, plasma concentrations of inflammatory cytokines were associated with the severity of the PCAS but were no different in the 33 °C or 36 °C groups.[58]

6.3. Oxygen

Several observational studies have documented an association between hyperoxia and poor neurological outcome among post-cardiac arrest patients. In a meta-analysis of observational studies, hyperoxia was associated with increased in-hospital mortality (OR 1.40; 95%CI 1.02–1.93; 8 studies) but not worse neurological outcome (OR 1.62; 95%CI 0.87–3.02; 2 studies); however, the results were inconsistent in subgroup and sensitivity analyses.[59]

6.4. Coronary revascularisation

Early cardiac catheterisation after cardiac arrest associated with ST-elevation myocardial infarction (STEMI) is now established practice, but in post-cardiac arrest patients without STEMI the role of early cardiac catheterisation remains controversial.

Among 269 patients with cardiac arrest caused by a ventricular arrhythmia without STEMI, 122 (45.4%) received cardiac catheterisation while comatose (early cardiac catheterisation).[60] Acute coronary occlusion was detected in 26.6% of patients treated with early cardiac catheterisation compared with 29.3% of patients treated with late cardiac catheterisation. Patients treated with early cardiac catheterisation were more likely to survive to hospital discharge compared with those not treated with cardiac catheterisation (65.6% vs. 48.6%; $p = 0.017$). In a multivariate regression model, early cardiac catheterisation was independently associated with a significant reduction in the risk of death (OR 0.35; 95%CI 0.18–0.70; $p = 0.003$).

In a meta-analysis of observational studies of OHCA patients, survival was associated with acute coronary angiography: in comparison with controls who did not undergo early angiography the odds ratio for survival with good neurological outcome was 2.20 (95%CI 1.46–3.32).[61]

7. Prognostication

In recent years, there has been a considerable quantity of data published on the topic of prognostication in the comatose post-cardiac arrest patient. Much of these data are complex and because they are all observational they are prone to bias, particularly the problem of self-fulfilling prophecy (the results of tests leading to withdrawal of life sustaining treatment (WLST)). It is timely therefore that members of European Resuscitation Council and the European Society of Intensive Care Medicine have collaborated to publish an advisory statement on prognostication in comatose survivors of cardiac arrest.[62] These guidelines emphasise the importance of using multiple modalities and delaying prognostication sufficiently to enable full clearance of sedation and neuromuscular blocking drugs. In the first such collaboration, these guidelines have been co-published in *Resuscitation* and *Intensive Care Medicine*.

There are many data showing that clinicians have been attempting prognostication far too early in comatose post-cardiac arrest patients. Among 89 patients treated with therapeutic hypothermia in a community-based hospital in Minnesota, USA and subsequently discharged alive, ten remained comatose and apnoeic >72 h after rewarming despite eventually regaining consciousness.[63]

There are conflicting data on the value of regional cerebral oxygen saturation (rSO_2) measured by near-infrared spectroscopy (NIRS) after cardiac arrest to predict neurological outcome. Among 60 post-cardiac arrest patients who underwent NIRS monitoring after ROSC, rSO_2 values were significantly lower in patients with a poor outcome but their ability to predict a poor neurological outcome was limited.[64]

8. Cardiac arrest centres

The question of whether OHCA patients should be transported directly to cardiac arrest centres for their treatment continues to be debated. London is one of the few centres in the world that has already regionalised the treatment of cardiac arrest patients. Since September 2010, post-cardiac patients with evidence of STEMI have been transported to one of eight 'heart attack centres' where there are cardiac catheterisation laboratories available 24 h a day seven days a week. During a one-year period from 1st April 2011, the London Ambulance Service transported 206 OHCA patients with clear evidence of STEMI to heart attack centres.[65] The rate of survival to discharge for these patients was an impressive 66%.

9. Ethics

Problems relating to do not attempt cardiopulmonary resuscitation (DNACPR) decisions led to 331 newspaper reports over a 10 year period.[66] Xanthos calls for better integration of CPR decisions with overall end of life care planning.[67] Such integration is supported by results from two systematic reviews[68,69] and evaluations of a universal treatment options form.[70,71]

Conflicts of interest

JPN is Editor-in-Chief of Resuscitation. JPO, MJAP, GDP and JS are Editors of Resuscitation. JPO is on the Science Advisory Board for ZOLL Circulation and 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). GDP is Co-Chair of the Basic Life Support Task Force of the International Liaison Committee on Resuscitation. JS is Co-Chair of the Advanced Life Support Task Force of the International Liaison Committee on Resuscitation.

References

1. Perkins GD, Jacobs IG, Nadkarni VM, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein resuscitation registry templates for out-of-hospital cardiac arrest. Resuscitation 2014, http://dx.doi.org/10.1016/j.resuscitation.2014.11.002.
2. Nolan JP, Soar J, Smith GB, et al. Incidence and outcome of in-hospital cardiac arrest in the United Kingdom National Cardiac Arrest Audit. Resuscitation 2014;85:987–92.
3. Husband A, Mercer I, Detering KM, Eastwood GM, Jones DA. The epidemiology of respiratory arrests in a teaching hospital. Resuscitation 2014;85:364–8.
4. Bray JE, Di Palma S, Jacobs I, Straney L, Finn J. Trends in the incidence of presumed cardiac out-of-hospital cardiac arrest in Perth, Western Australia, 1997–2010. Resuscitation 2014;85:757–61.
5. Andrew E, Nehme Z, Lijovic M, Bernard S, Smith K. Outcomes following out-of-hospital cardiac arrest with an initial cardiac rhythm of asystole or pulseless electrical activity in Victoria, Australia. Resuscitation 2014;85:1633–9.
6. Kitamura T, Morita S, Kiyohara K, et al. Trends in survival among elderly patients with out-of-hospital cardiac arrest: a prospective, population-based observation from 1999 to 2011 in Osaka. Resuscitation 2014;85:1432–8.
7. Soholm H, Bro-Jeppesen J, Lippert FK, et al. Resuscitation of patients suffering from sudden cardiac arrests in nursing homes is not futile. Resuscitation 2014;85:369–75.
8. Gupta P, Tang X, Gall CM, Lauer C, Rice TB, Wetzel RC. Epidemiology and outcomes of in-hospital cardiac arrest in critically ill children across hospitals of varied center volume: a multi-center analysis. Resuscitation 2014;85:1473–9.
9. Kitamura T, Kiyohara K, Nitta M, Nadkarni VM, Berg RA, Iwami T. Survival following witnessed pediatric out-of-hospital cardiac arrests during nights and weekends. Resuscitation 2014;85:1692–8.
10. Eccles SR, Subbe C, Hancock D, Thomson N. CREWS: improving specificity whilst maintaining sensitivity of the National Early Warning Score in patients with chronic hypoxaemia. Resuscitation 2014;85:109–11.
11. Badriyah T, Briggs JS, Meredith P, et al. Decision-tree early warning score (DTEWS) validates the design of the National Early Warning Score (NEWS). Resuscitation 2014;85:418–23.
12. Romero-Brufau S, Huddleston JM, Naessens JM, et al. Widely used track and trigger scores: are they ready for automation in practice. Resuscitation 2014;85:549–52.
13. Chen J, Ou L, Hillman K, et al. The impact of implementing a rapid response system: a comparison of cardiopulmonary arrests and mortality among four teaching hospitals in Australia. Resuscitation 2014;85:1275–81.
14. Petersen JA, Mackel R, Antonsen K, Rasmussen LS. Serious adverse events in a hospital using early warning score – what went wrong. Resuscitation 2014;85:1699–703.
15. Georgiou M, Papathanassoglou E, Xanthos T. Systematic review of the mechanisms driving effective blood flow during adult CPR. Resuscitation 2014;85:1586–93.
16. Cheng A, Overly F, Kessler D, et al. Perception of CPR quality: influence of CPR feedback, Just-in-Time CPR training and provider role. Resuscitation 2014;87C:44–50.
17. Kampmeier TG, Lukas RP, Steffler C, et al. Chest compression depth after change in CPR guidelines – improved but not sufficient. Resuscitation 2014;85:503–8.
18. Kirkbright S, Finn J, Tohira H, Bremner A, Jacobs I, Celenza A. Audiovisual feedback device use by health care professionals during CPR: a systematic review and meta-analysis of randomised and non-randomised trials. Resuscitation 2014;85:460–71.
19. Yeung J, Davies R, Gao F, Perkins GD. A randomised control trial of prompt and feedback devices and their impact on quality of chest compressions – a simulation study. Resuscitation 2014;85:553–9.
20. Alonso E, Ruiz J, Aramendi E, et al. Reliability and accuracy of the thoracic impedance signal for measuring cardiopulmonary resuscitation quality metrics. Resuscitation 2014;88C:28–34.
21. Ayala U, Eftestol T, Alonso E, et al. Automatic detection of chest compressions for the assessment of CPR-quality parameters. Resuscitation 2014;85:957–63.
22. Alonso E, Gonzalez-Otero D, Aramendi E, et al. Can thoracic impedance monitor the depth of chest compressions during out-of-hospital cardiopulmonary resuscitation. Resuscitation 2014;85:637–43.
23. Gohier F, Dellimore KH, Scheffer C. Development of a real-time feedback algorithm for chest compression during CPR without assuming full chest decompression. Resuscitation 2014;85:820–5.
24. Beesems SG, Koster RW. Accurate feedback of chest compression depth on a manikin on a soft surface with correction for total body displacement. Resuscitation 2014;85:1439–43.
25. Wutzler A, Bannehr M, von Ulmenstein S, et al. Performance of chest compressions with the use of a new audio-visual feedback device: a randomized manikin study in health care professionals. Resuscitation 2015;87:81–5.
26. Drennan IR, Lin S, Thorpe KE, Morrison LJ. The effect of time to defibrillation and targeted temperature management on functional survival after out-of-hospital cardiac arrest. Resuscitation 2014;85:1623–8.
27. Lijovic M, Bernard S, Nehme Z, Walker T, Smith K, On behalf of the Victorian Ambulance Cardiac Arrest Registry Steering C. Public access defibrillation – results from the Victorian Ambulance Cardiac Arrest Registry. Resuscitation 2014;85:1739–44.
28. Rodriguez-Nunez A, Lopez-Herce J, del Castillo J, Bellon JM, Iberian-American Paediatric Cardiac Arrest Study Network R. Shockable rhythms and defibrillation during in-hospital pediatric cardiac arrest. Resuscitation 2014;85:387–91.
29. Lemkin DL, Witting MD, Allison MG, Farzad A, Bond MC, Lemkin MA. Electrical exposure risk associated with hands-on defibrillation. Resuscitation 2014;85:1330–6.
30. Nevin DG, Green SJ, Weaver AE, Lockey DJ. An observational study of paediatric pre-hospital intubation and anaesthesia in 1933 children attended by a physician-led, pre-hospital trauma service. Resuscitation 2014;85:189–95.
31. Kleber C, Giesecke MT, Lindner T, Haas NP, Buschmann CT. Requirement for a structured algorithm in cardiac arrest following major trauma: epidemiology, management errors, and preventability of traumatic deaths in Berlin. Resuscitation 2014;85:405–10.
32. Schober A, Sterz F, Handler C, et al. Cardiac arrest due to accidental hypothermia – a 20 year review of a rare condition in an urban area. Resuscitation 2014;85:749–56.
33. Claesson A, Lindqvist J, Herlitz J. Cardiac arrest due to drowning – changes over time and factors of importance for survival. Resuscitation 2014;85:644–8.
34. Quan L, Mack CD, Schiff MA. Association of water temperature and submersion duration and drowning outcome. Resuscitation 2014;85:790–4.
35. Suominen PK, Sutinen N, Valle S, Olkkola KT, Lonnqvist T. Neurocognitive long term follow-up study on drowned children. Resuscitation 2014;85:1059–64.
36. Szpilman D, Webber J, Quan L, et al. Creating a drowning chain of survival. Resuscitation 2014;85:1149–52.
37. Voss S, Rhys M, Coates D, et al. How do paramedics manage the airway during out of hospital cardiac arrest. Resuscitation 2014;85:1662–6.
38. McMullan J, Gerecht R, Bonomo J, et al. Airway management and out-of-hospital cardiac arrest outcome in the CARES registry. Resuscitation 2014;85:617–22.
39. Diggs LA, Yusuf JE, De Leo G. An update on out-of-hospital airway management practices in the United States. Resuscitation 2014;85:885–92.
40. Middleton PM, Simpson PM, Thomas RE, Bendall JC. Higher insertion success with the i-gel supraglottic airway in out-of-hospital cardiac arrest: a randomised controlled trial. Resuscitation 2014;85:893–7.
41. Wik L, Olsen JA, Persse D, et al. Manual vs. integrated automatic load-distributing band CPR with equal survival after out of hospital cardiac arrest. The randomized CIRC trial. Resuscitation 2014;85:741–8.
42. Perkins GD, Lall R, Quinn T, et al. Mechanical versus manual chest compression for out-of-hospital cardiac arrest (PARAMEDIC): a pragmatic, cluster randomised controlled trial. Lancet 2014.

43. Rubertsson S, Lindgren E, Smekal D, et al. Mechanical chest compressions and simultaneous defibrillation vs conventional cardiopulmonary resuscitation in out-of-hospital cardiac arrest: the LINC randomized trial. JAMA 2014;311:53–61.
44. Smekal D, Lindgren E, Sandler H, Johansson J, Rubertsson S. CPR-related injuries after manual or mechanical chest compressions with the LUCAS device: a multicentre study of victims after unsuccessful resuscitation. Resuscitation 2014;85:1708–12.
45. Sakamoto T, Morimura N, Nagao K, et al. Extracorporeal cardiopulmonary resuscitation versus conventional cardiopulmonary resuscitation in adults with out-of-hospital cardiac arrest: a prospective observational study. Resuscitation 2014;85:762–8.
46. Stub D, Bernard S, Pellegrino V, et al. Refractory cardiac arrest treated with mechanical CPR, hypothermia, ECMO and early reperfusion (the CHEER trial). Resuscitation 2015;86:88–94.
47. Lin S, Callaway CW, Shah PS, et al. Adrenaline for out-of-hospital cardiac arrest resuscitation: a systematic review and meta-analysis of randomized controlled trials. Resuscitation 2014;85:732–40.
48. Layek A, Maitra S, Pal S, Bhattacharjee S, Baidya DK. Efficacy of vasopressin during cardio-pulmonary resuscitation in adult patients: a meta-analysis. Resuscitation 2014;85:855–63.
49. Warren SA, Huszti E, Bradley SM, et al. Adrenaline (epinephrine) dosing period and survival after in-hospital cardiac arrest: a retrospective review of prospectively collected data. Resuscitation 2014;85:350–8.
50. Sutton RM, Friess SH, Maltese MR, et al. Hemodynamic-directed cardiopulmonary resuscitation during in-hospital cardiac arrest. Resuscitation 2014;85:983–6.
51. Rognas L, Hansen TM, Kirkegaard H, Tonnesen E. Predicting the lack of ROSC during pre-hospital CPR: should an end-tidal CO_2 of 1.3 kPa be used as a cut-off value? Resuscitation 2014;85:332–5.
52. Rudolph SS, Sorensen MK, Svane C, Hesselfeldt R, Steinmetz J. Effect of prehospital ultrasound on clinical outcomes of non-trauma patients – a systematic review. Resuscitation 2014;85:21–30.
53. Zanatta M, Benato P, Cianci V. Ultrasound guided chest compressions during cardiopulmonary resuscitation. Resuscitation 2015;87:e13–4.
54. Doepp Connolly F, Reitemeier J, Storm C, Hasper D, Schreiber SJ. Duplex sonography of cerebral blood flow after cardiac arrest – a prospective observational study. Resuscitation 2014;85:516–21.
55. Callaway CW, Schmicker RH, Brown SP, et al. Early coronary angiography and induced hypothermia are associated with survival and functional recovery after out-of-hospital cardiac arrest. Resuscitation 2014;85:657–63.
56. Ibrahim K, Christoph M, Schmeinck S, et al. High rates of prasugrel and ticagrelor non-responder in patients treated with therapeutic hypothermia after cardiac arrest. Resuscitation 2014;85:649–56.
57. Maze R, Le May MR, Froeschl M, et al. Endovascular cooling catheter related thrombosis in patients undergoing therapeutic hypothermia for out of hospital cardiac arrest. Resuscitation 2014;85:1354–8.
58. Bro-Jeppesen J, Kjaergaard J, Wanscher M, et al. The inflammatory response after out-of-hospital cardiac arrest is not modified by targeted temperature management at 33 °C or 36 °C. Resuscitation 2014;85:1480–7.
59. Wang CH, Chang WT, Huang CH, et al. The effect of hyperoxia on survival following adult cardiac arrest: a systematic review and meta-analysis of observational studies. Resuscitation 2014;85:1142–8.
60. Hollenbeck RD, McPherson JA, Mooney MR, et al. Early cardiac catheterization is associated with improved survival in comatose survivors of cardiac arrest without STEMI. Resuscitation 2014;85:88–95.
61. Camuglia AC, Randhawa VK, Lavi S, Walters DL. Cardiac catheterization is associated with superior outcomes for survivors of out of hospital cardiac arrest: review and meta-analysis. Resuscitation 2014;85:1533–40.
62. Sandroni C, Cariou A, Cavallaro F, et al. Prognostication in comatose survivors of cardiac arrest: an advisory statement from the European Resuscitation Council and the European Society of Intensive Care Medicine. Resuscitation 2014:1779–89.
63. Gold B, Puertas L, Davis SP, et al. Awakening after cardiac arrest and post-resuscitation hypothermia: are we pulling the plug too early. Resuscitation 2014;85:211–4.
64. Storm C, Leithner C, Krannich A, et al. Regional cerebral oxygen saturation after cardiac arrest in 60 patients – a prospective outcome study. Resuscitation 2014;85:1037–41.
65. Fothergill RT, Watson LR, Virdi GK, Moore FP, Whitbread M. Survival of resuscitated cardiac arrest patients with ST-elevation myocardial infarction (STEMI) conveyed directly to a Heart Attack Centre by ambulance clinicians. Resuscitation 2014;85:96–8.
66. Beed M, de Beer T, Brindley PG. Two decades of British newspaper coverage regarding do not attempt cardiopulmonary resuscitation decisions: lessons for clinicians. Resuscitation 2015;86:31–7.
67. Xanthos T. 'Do not attempt cardiopulmonary resuscitation' or 'allowing natural death'? The time for resuscitation community to review its boundaries and its terminology. Resuscitation 2014;85:1644–5.
68. Field RA, Fritz Z, Baker A, Grove A, Perkins GD. Systematic review of interventions to improve appropriate use and outcomes associated with do-not-attempt-cardiopulmonary-resuscitation decisions. Resuscitation 2014;85:1418–31.
69. Mockford C, Fritz Z, George R, et al. Do not attempt cardiopulmonary resuscitation (DNACPR) orders: a systematic review of the barriers and facilitators of decision-making and implementation. Resuscitation 2015;88:99–113.
70. Fritz Z, Malyon A, Frankau JM, et al. The Universal Form of Treatment Options (UFTO) as an alternative to Do Not Attempt Cardiopulmonary Resuscitation (DNACPR) orders: a mixed methods evaluation of the effects on clinical practice and patient care. PLoS ONE 2013;8:e70977.
71. Fritz ZB, Heywood RM, Moffat SC, Bradshaw LE, Fuld JP. Characteristics and outcome of patients with DNACPR orders in an acute hospital; an observational study. Resuscitation 2014;85:104–8.

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