Out-of-hospital cardiac arrest termination of resuscitation with ongoing CPR: an observational study

Yates EJ[1*§], Schmidbauer S[2], Smyth MA[3,4], Ward M[4], Dorrian S[5], Siriwardena AN[6], Friberg H[2], Perkins GD[1]

[1] Critical Care Unit, Heartlands Hospital, University Hospitals Birmingham NHS Foundation Trust, West Midlands, UK
[2] Lund University, Skåne University Hospital, Dept. of Clinical Sciences, Anaesthesiology and Intensive Care, Malmö, Sweden; Center for Cardiac Arrest at Lund University, Lund University, Lund, Sweden
[3] Warwick Clinical Trials Unit, University of Warwick, Coventry, UK
[4] West Midlands Ambulance Service NHS Foundation Trust, West Midlands, UK
[5] Department of Emergency Medicine, University Hospitals Birmingham NHS Foundation Trust, West Midlands, UK
[6] Community and Health Research Unit, School of Health and Social Care, College of Social Science, University of Lincoln, Lincoln, UK

* These authors contributed equally to this work
[§] Corresponding author

Abstract

Introduction: Termination of resuscitation guidelines for out-of-hospital cardiac arrest can identify patients in whom continuing resuscitation has little chance of success. This study examined the outcomes of patients transferred to hospital with ongoing CPR. It assessed outcomes for those who would have met the universal prehospital termination of resuscitation criteria (no shocks administered, unwitnessed by emergency medical services, no return of spontaneous circulation).

Methods: A retrospective cohort study of consecutive adult patients who were transported to hospital with ongoing CPR was conducted at three hospitals in the West Midlands, UK between September 2016 and November 2017. Patient characteristics, interventions and response to treatment (ROSC, survival to discharge) were identified.

Results: 227 (median age 69 years, 67.8% male) patients were identified. 89 (39.2%) met the universal prehospital termination of resuscitation criteria. Seven (3.1%) were identified with a potentially reversible cause of cardiac arrest. After hospital arrival, patients received few specialist interventions that were not available in the prehospital setting. Most (n=210, 92.5%) died in the emergency department. 17 were admitted (14 to intensive care), of which 3 (1.3%) survived to hospital discharge. There were no survivors (0%) in those who met the criteria for universal prehospital termination of resuscitation.

Conclusion: Overall survival amongst patients transported to hospital with ongoing CPR was very poor. Application of the universal prehospital termination of resuscitation rule, in patients without obvious reversible causes of cardiac arrest, would have allowed resuscitation to have been discontinued at the scene for 39.2% of patients who did not survive.

Keywords: Cardiac arrest; out-of-hospital cardiac arrest; OHCA; cardiopulmonary resuscitation; CPR; termination of resuscitation; TOR; ongoing CPR, observational; universal prehospital termination of resuscitation rule; return of spontaneous circulation; ROSC; survival to discharge; West Midlands; UK; decision support techniques

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Introduction

Ambulance services in England respond to over 60,000 out-of-hospital cardiac arrests (OHCA), each year [1]. Resuscitation is attempted in around half of cases and return of spontaneous circulation (ROSC), at time of hospital transfer, is achieved in only 25.8% [2]. Reported estimates for survival to hospital discharge and favourable neurological outcomes are 9.4% and 8.5%, respectively [3]. Most survivors of OHCA achieve ROSC early in the resuscitation attempt [4], whereas poor survival is typical for patients in whom ROSC is not achieved and transport to hospital with ongoing CPR is required [5].

Transportation with ongoing CPR has recognised risks for both patients and Emergency Medical Services (EMS) personnel. Interruptions of CPR are associated with worse survival [6]. Previous studies have demonstrated the inability to provide high quality manual CPR during the extrication of patients on a stretcher, both down stairs and through confined corridors [7]. Additionally, adverse CPR quality has been recognised due to critical acceleration forces, occurring during ambulance transport, particularly at slower speeds [8]. As such, extrication and transportation to hospital may hinder resuscitation success versus remaining on scene [9]. Furthermore, ongoing CPR during transport typically requires the provider to be unrestrained. This increases the risk of injury in the event of a collision [10], as well as potential injuries due to high forces of acceleration and deceleration whilst travelling unrestrained [11].

Termination of resuscitation (TOR) guidelines for OHCA have been derived to identify patients in whom continuing resuscitation has little chance of success. TOR at the scene of OHCA occurs in approximately one third of cases in England [12]. In the UK, the Joint Royal Colleges Ambulance Liaison Committee (JRCALC) Recognition of Life Extinct (ROLE) Clinical Practice Guideline [13] informs clinicians responding to OHCA of TOR decisions (*Appendix 1*). ROLE allows TOR if the patient remains asystolic after 20 minutes of advanced life support (ALS), in the absence of a special circumstance (e.g. pregnancy, suspected poisoning or drug overdose). In patients not fulfilling the ROLE criteria, continued resuscitation is expected.

Resuscitation Council (UK) guidelines suggest that there is little to be gained from transporting patients to hospital, who have not obtained ROSC on scene [14]. Basic life support (BLS), common to pre and in-hospital settings, remains the key to successful resuscitation, over more advanced procedures [6]. The universal prehospital termination of resuscitation clinical prediction rule [15, 16] identifies patients, who despite resuscitation attempts, do not achieve ROSC prior to transport and do not require shocks, where the arrest was not witnessed by EMS personnel. Prospective validation of this rule, among patients with OHCA of presumed cardiac aetiology, demonstrated 100% positive predictive value (PPV) for death, suggesting it may be reasonable to stop resuscitation and avoid the risk and resource implications of transfer to hospital with ongoing CPR [17].

This study sought to explore patient characteristics, interventions provided and outcomes in patients transferred to hospital with ongoing CPR. A secondary aim was to determine how many transported patients, would fulfil the universal prehospital termination of resuscitation criteria.

Methods

Study design

The study was a retrospective cohort study. Consecutive patients presenting in cardiac arrest between September 2016 and November 2017 to one of three NHS acute hospitals in the West Midlands, UK were eligible for inclusion. This was a convenience sample based on the availability of electronic patient records covering this period.

Setting

National Health Service (NHS) ambulance services are responsible for prehospital resuscitation attempts in accordance with national guidelines [14]. Ambulance service resuscitation includes advanced airway management, drug administration (adrenaline and amiodarone only) and external defibrillation. The ROLE criteria outcomes above were in operation during the conduct of the study.

The hospitals included in this study serve a population of 1.2 million [18], covering urban and rural settings. The hospitals provide access to 24/7 diagnostic imaging (echocardiography, CT scanning) and specialist teams (intensive care, cardiology [including percutaneous coronary intervention (PCI) at one site]). None of the hospitals provide extracorporeal life support (e-CPR). Information about patient characteristics, interventions provided and outcomes were extracted from routine electronic ambulance service and hospital records. The study was assessed in accordance with the Health Research Authority Decision Tool [19]. Institutional approval was granted by the Trust Audit and Effectiveness team (approval number 4198).

Study population

Electronic records were screened to identify all patients aged ≥18 years who were transported to hospital following OHCA. Patients were eligible for inclusion if they had a confirmed OHCA and were transported to hospital with ongoing CPR. Patients were excluded where they had not experienced OHCA, the first cardiac arrest occurred during ambulance transport to hospital, or where patients were transported after ROSC with no need for ongoing CPR.

Data extraction

Patient characteristics, circumstances of the arrest, treatments administered before and after arrival at hospital and outcomes (ROSC, survival to discharge) were recorded in accordance with the Utstein Resuscitation Registry Template [20]. Comorbidities, where present, were listed by Charlson groupings [21], and neurological outcome (at hospital discharge) according to Cerebral Performance Category (CPC) [22].

Each case was assessed to determine if any special circumstances (i.e. potentially reversible causes such as hypothermia, drug overdose, *Appendix 1*) were present and whether the criteria for the universal prehospital termination of resuscitation clinical prediction rule were met (no ROSC prior to transport, no shocks administered and arrest not EMS witnessed) [17].

Statistical analysis

Statistical analysis was performed using R (version 3.3.3). Continuous variables were tested for normality by histogram inspection and the Shapiro-Wilk test. For sample distribution testing between the three groups, Kruskal-Wallis and one-way analysis of variance (ANOVA) tests were used. Post hoc pairwise comparisons were performed using Conover, further adjusted by the Holm family-wise error rate (FWER) method. Fisher's exact test with follow-up pairwise comparison of proportions, adjusted for multiple comparisons by Bonferroni correction, was used for count data. P values of less than 0.05 were considered to be statistically significant.

Results

576 patients were identified as potential cases of cardiac arrest, of which 557 records were individually reviewed (*Figure 1*). 330 patients were excluded (either due to lack of confirmation of OHCA or lack of ongoing CPR), leading to 227 eligible patients. 89 (39.2%) met the universal prehospital termination of resuscitation criteria (*Figure 2*) whilst seven (3.1%) had an identified special circumstance (suspected poisoning or drug overdose accounted for six cases and pregnancy, one case). Six (85.7%) of these special circumstance patients also fulfilled the universal prehospital termination of resuscitation criteria. 137 (60.4%) met neither the universal prehospital termination of resuscitation criteria nor had an identified special circumstance. No cases of traumatic cardiac arrest were identified.

Patient characteristics

The median age was 69 (IQR 56-79) years. Those in the *Special circumstance* group were younger than both *uTOR terminate* ($p<0.001$) and *Non-uTOR terminate* ($p<0.001$) groups. 154 (67.8%) patients were male, 114 (56.7%) received bystander CPR, 148 (65.2%) had comorbidities and 62 (27.3%) were living independently; however none of these characteristics were significantly different between groups (*Table 1*, *Supplementary Table 1*). Home or residence was the most common location of cardiac arrest in all groups (n=160, 70.5%). Asystole was the most common presenting rhythm overall (n=82, 36.1%), significantly more likely in both *uTOR terminate* and *Special circumstance* than *Non-uTOR terminate* ($p<0.001$).

Neither on-scene (mean 38 minutes [SD 11]) nor in-transit (median 9 minutes [IQR 7-12]) resuscitation times were significantly different between groups (*Supplementary Table 2*), however when including ambulance response times, *Non-uTOR terminate* had longer call to scene departure and call to hospital arrival times ($p<0.05$ and $p<0.01$, respectively) than *uTOR terminate*.

Interventions provided before hospital arrival

Adrenaline was almost universally administered (n=225, 99.1%) at a median time between emergency call to first drug administration of 21 minutes (IQR 17-27). Only patients in the *Non-uTOR terminate* group received prehospital defibrillations with a median of two shocks (IQR 1-5) at a median time from call to first defibrillation of 11 minutes (IQR 8-15). Supraglottic airway devices were the most common airway (n=114, 50.2%), and peripheral intravenous cannulation, the most common vascular access (n=126, 55.5%), however no significant inter-group differences were observed for either. Low rates of mechanical CPR were observed (n=1, 0.7%, *Table 2*).

Interventions provided after hospital arrival

After hospital arrival, patients received few specialist interventions that were not available in the prehospital setting. 80 (35.2%) patients received any kind of in-hospital intervention, with *uTOR terminate* being significantly less likely than both *Special circumstance* and *Non-uTOR terminate* ($p<0.05$ and $p<0.01$, respectively) to do so. The *Non-uTOR terminate* group was more likely to receive echocardiography ($p<0.05$) and advanced airway support ($p<0.05$) than *uTOR terminate*, whilst *Special circumstance* patients were more likely than both *uTOR terminate* ($p<0.01$) and *Non-uTOR terminate* ($p<0.05$) to receive non-JRCALC drugs (e.g. thrombolytic therapy, vasoactive drugs).

Other interventions in hospital were received by six (2.6%) patients (more likely in *Special circumstance* than *Non-uTOR terminate* [$p<0.05$]). Such interventions included: intra-aortic balloon pump insertion (n=1), external cardiac pacing (n=2), implantable cardioverter defibrillator insertion (n=1), permanent pacemaker insertion (n=1) and peri-mortem Caesarian section (n=1).

Patient outcomes

Overall patient outcomes were poor with an overall survival to hospital discharge of 1.3% (*Table 3*). The *Non-uTOR terminate* group was more likely than the *uTOR terminate* group to have ROSC before ($p<0.001$) and after hospital arrival ($p<0.01$). Most (n=210, 92.5%) patients died in the emergency department; median whole group time from hospital arrival to TOR decision was 13 minutes (IQR 8-20); this was significantly shorter in the *uTOR terminate* group than either other group ($p<0.05$). 17 (7.5%) patients were admitted to hospital of which 14 (82.4%) were to intensive care (including 3 patients from the *uTOR terminate* group). No

Special circumstance patients were admitted to hospital. The electronic supplementary materials (*Supplementary Tables 3 and 4*) detail cause of death and time from ROSC to withdrawal of treatment.

The three (1.3%) survivors all had VF as the presenting rhythm, received between 5-8 shocks prehospitally and underwent cardiac catheterisation in hospital. All three patients were discharged home with a positive neurological outcome. No patients from the *uTOR terminate* group survived to hospital discharge; the universal prehospital termination of resuscitation rule therefore correctly identified non-survivors in this cohort with a PPV of 100% (95% CI 97.6-100.0%).

Discussion

The main finding of this study was of poor overall survival (1.3%) amongst patients transported to hospital with ongoing CPR following OHCA. Few patients received an in-hospital therapeutic (versus diagnostic) intervention that was not available in the prehospital setting. The universal prehospital termination of resuscitation clinical prediction rule correctly predicted universally fatal outcomes for patients meeting all criteria for termination (0% survival). If the universal prehospital termination of resuscitation clinical prediction rule was applied at the scene, the number transported to hospital would have reduced by 40%.

This study identified limited benefits from transport to hospital with ongoing CPR. With the exception of three patients with shock-refractory VF, outcomes were universally fatal. The decision to transport a patient with ongoing CPR must balance the risks and benefits of such a decision. With little to gain, risks to both patient and emergency medical providers associated with the transfer of a patient with ongoing CPR weigh heavy. The act of transferring the patient from the scene of the cardiac arrest to the ambulance and then to hospital may lead to reduction in the quality of CPR [23]. Some observational studies have reported reduced chest compression depth and more interruptions during ambulance transport compared to resuscitation at the site of the cardiac arrest [24, 25, 26] although this is not universally observed [27]. Un-restrained ambulance staff are at risk of musculoskeletal injuries from acceleration forces during emergency ambulance transport [8]. Emergency ambulance transfers place ambulance staff and others at risk of death or serious injury (300 crashes resulting in 500 injuries and 3-5 fatalities per year) [28]. Transfer to hospital also impacts emergency department space and staff resources; it separates the patient from the family and displaces them to a busy and unfamiliar environment. Despite the best efforts of ED staff it is often difficult to provide the family with a quiet, dignified environment.

The universal prehospital termination of resuscitation clinical prediction rule was originally derived from Canadian OHCA data, yielding separate rules for BLS [16] and ALS [15] response. Subsequent prospective validation (expanded across North America in 2,415 patients) [17] simplified the rule, by suggesting the three BLS criteria had 100% PPV for death. Prospective validation in other countries, including Japan (11,505 patients [29]) and Canada (2,421 patients [30]) have remained consistent, supporting the generalisability of this clinical prediction rule for all OHCA of presumed cardiac origin. While our results show some promise for the utilisation of this rule also in a wider OHCA context, this finding has to be interpreted with caution due to the low number of cases with non-cardiac causes of arrest in this study's population.

Extrapolating data from the national out of hospital cardiac arrest registry [2] indicates that there would have been approximately 800 cardiac arrests in the population served by these hospitals during the study period. Applying the findings of this study gives an overall transport rate with ongoing CPR of 28% of resuscitation attempts. If these figures are scaled up across the UK (where there are approximately 30,000 OHCAs with attempted resuscitation, each year [1]), it indicates that there are approximately 8400 emergency transports with ongoing CPR, from which our results indicate there may be as little as 110 survivors. Application of the universal TOR clinical prediction rule could identify 3,290 cases that were transported to hospital, in spite of there being no realistic chance of survival.

This study has the following limitations. Firstly, the study was conducted at three hospital centres, all of which were served by a single ambulance service; consequently the generalisability of the findings to the rest of the UK is unexplored. Secondly, the study had a relatively small sample size (n=227), with very few special circumstances (n=7). The derived universal prehospital termination of resuscitation clinical prediction rule PPV confidence interval is relatively wide when considering futility decisions. Thirdly, ongoing CPR determination required inferences from case notes and timings; therefore, a minority of patients may have been inappropriately included. Fourthly, the vulnerability of cardiac arrest TOR rules to self-fulfilling prophecy is recognised [31]; earlier TOR for certain patient groups, irrespective of reason, will directly lead to poorer prognosis in that group. This positive feedback vulnerability may have influenced the interventions received and outcomes of patients with unfavourable prognostic factors in this study. Fifthly, we did not measure the quality of CPR during ambulance transfer so the inference about impaired quality drawn from other studies was not formally assessed. Finally, the number of patients with potentially reversible causes of cardiac arrest in this study was small, which limits the certainty that these results are generalisable to this patient group.

Future research

This study provides findings which have the potential to influence resuscitation practice. The next steps are to confirm the generalisability of the findings to the whole population with a UK-wide study. This expansion

should be supplemented by qualitative work addressing the acceptability of on scene termination of resuscitation, from both a patient and EMS personnel perspective. The potential for organ donation following unsuccessful resuscitation creates an ethical dilemma; increasing on scene TOR may result in reduced donation. Consequently, further work is required to explore such associations. Finally, although outside the scope of this study (which examined only patients who were transported to hospital), recent observational data suggest that a 20 minute window for termination of resuscitation may be premature [32]. Further work to explore the effects of extending the 20 minute window for ROLE requires further study.

Conclusion

Overall survival amongst patients transported to hospital with ongoing CPR was very poor. Application of the universal prehospital termination of resuscitation rule, in patients without obvious reversible causes of cardiac arrest, would have allowed resuscitation to have been discontinued at the scene for 39.2% of patients who did not survive.

Conflicts of Interest

Yates EJ, Schmidbauer S, Smyth AM, Ward M, Dorrian S, Siriwardena AN, Friberg H; conflicts of interest: none. Perkins GD; editor for Resuscitation Journal.

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Legends to figures

Figure 1. Flow chart of case identification and cohort grouping. 6 of 7 (85.7%) patients in the Special circumstance group also fulfilled the universal prehospital termination of resuscitation clinical prediction rule criteria.

Figure 2. Venn diagram representing cross-over between each of the three universal prehospital termination of resuscitation clinical prediction rule variables and showing relative patient counts (and %) in each.

Table 1. Patient characteristics, separated by cohort group. Bystander CPR only relevant to patients without EMS witnessed OHCA (n=201). Bystander AED usage only relevant to those who received bystander CPR. † Statistically significant inter-group distribution testing, though post hoc pairwise comparisons not statistically significant. Abbreviations: IQR (Interquartile Range), EMS (Emergency Medical Services), AED (Automated External Defibrillator), VF (Ventricular Fibrillation), VT (Ventricular Tachycardia), PEA (Pulseless Electrical Activity).

Table 2. Interventions provided, separated by cohort group. Abbreviations: OPA (Oro-Pharyngeal Airway), SAD (Supraglottic Airway Device), ETT (Endotracheal Tube), IV (Intravenous), IO (Intraosseous), CT (Computerised Tomography), TTM (Targeted Temperature Management), JRCALC (Joint Royal Colleges Ambulance Liaison Committee).

Table 3. Patient outcomes, separated by cohort group. Abbreviations: ROSC (Return of Spontaneous Circulation), ITU (Intensive Therapy Unit), CPC (Cerebral Performance Category). † Patients sustaining a ROSC in-transit to hospital (ie. before hospital arrival, though not on scene).

Supplementary Table 1. Patient supplemental demographics, separated by cohort group.

Supplementary Table 2. Timings of cardiac arrest, separated by cohort group. † Statistically significant inter-group distribution testing, though post hoc pairwise comparisons not statistically significant. Abbreviations: IQR (Interquartile Range), SD (Standard Deviation), TOR (Termination of Resuscitation).

Supplementary Table 3. Coded causes of death, separated by cohort group. Abbreviations: COPD (Chronic Obstructive Pulmonary Disease), LRTI (Lower Respiratory Tract Infection).

Supplementary Table 4. Derived supplemental outcomes and timings for those patients surviving beyond the emergency department, though not surviving to hospital discharge, separated by cohort group. Abbreviations: ROSC (Return of Spontaneous Circulation), SD (Standard Deviation).