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

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## 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.

### 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

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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 min 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  $\geq 18$  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 (Fig. 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 (Fig. 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

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