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# Out-of-hospital cardiac arrest: prehospital management

**Lina Matuliauskaitė[1], Pranas Šerpytis[1,2,3,4]**

[1]*Vilnius University, faculty of medicine*

[2]*Vilnius University, faculty of medicine, Clinical Medicine Institute*

[3]*Vilnius University Hospital, Santaros Clinics, Heart and Vessels Clinic*

[4]*Emergency medicine center*

## ABSTRACT

**Background:** Out-of-hospital cardiac arrest has high rates of morbidity and mortality rates for patients.
**Objective:** Our aim was review the evidence for interventions commonly deployed in cardiac arrest management, examine the outcomes of patients transferred to hospital with on-going cardiopulmonary resuscitation and propose a successful pre-hospital resuscitation management strategy.
**Methods:** systemic analysis was grounded by academic articles, found in the following databases: PubMed, BioMedCentral, Cohrane Library, Science Direct, Embase. Search of academic articles has been performed according to the strategies, adapted to each database. Systemic summary contained random controlled researches, published in 2013-2018. A review and analysis of 21 publications were performed.
**Results and conclusion:**
1. The analysed articles demonstrates that, overall survival among patients, transported to the hospital with on-going cardiopulmonary resuscitation, was very poor.
3. Strengthening the early links in the pre-hospital management of cardiac arrest (cardiac arrest recognition, call for help, bystander cardiopulmonary resuscitation and bystander automated external defibrillators use) have the greatest potential to improve survival.
3. Team−focused cardiopulmonary resuscitation is a focused approach to cardiac arrest care that emphasizes early defibrillation and high quality, minimally interrupted chest compressions while deemphasizing endotracheal intubation and intravenous drug administration.
**Keywords:** cardiac arrest, resuscitation, dispatch, cardio-pulmonary resuscitation, ambulance, defibrillation, emergency medical services.

## Introduction

Out-of-hospital cardiac arrest (OHCA) is a global health problem, with survival varying greatly between communities (1). More than 356,000 out-of-hospital cardiac arrests (OHCA) occur each year while overall risk-adjusted survival remains 8.3% (2). Over the past decade, many clinical research reports have redefined our approach to cardiac arrest resuscitation, and over this time we have seen a slow trend toward improved outcomes. Pre-hospital medicine has led the charge for this revolution by emphasizing a standardized and simplified approach to cardiopulmonary resuscitation (CPR), focusing only on the most important interventions shown to improve patient outcomes, including return of spontaneous circulation (ROSC), survival to hospital admission, survival to hospital discharge and, most importantly, survival with intact neurologic function(3). Survival of patients with OHCA requires a coordinated set of actions, including immediate recognition of cardiac arrest and activation of the emergency response system, early CPR, rapid defibrillation, effective advanced life support, and integrated care after cardiac arrest. The chain of survival includes the community, emergency medical dispatch, and ambulance and hospital-based services. The medical literature has focused more on hospital and advanced life support treatments than it has on community treatment and issues related to basic life support. However, there has been increasing recognition of the importance of basic life support, the role of the community, and the key function of emergency medical dispatch in coordination of bystander CPR and early defibrillation (4).

## Materials and methods

A systemic analysis was grounded by academic articles, found in the following databases: PubMed, BioMedCentral, Cohrane Library, Science Direct, Embase. Search of academic articles has been performed according to the strategies, adapted to each database. The following keywords have been applied: „cardiac arrest ", „resuscitation ", „dispatch ", „cardio-pulmonary resuscitation ", „ambulance ", „defibrillation", „emergency medical services".

## Role of the community working with dispatch

The earlier CPR is started in OHCA, the more likely it is that the patient will survive (5). The medical dispatcher is the first responder at the scene, and can be the key to prompt recognition of cardiac arrest and initiation of bystander CPR. This strategy requires proper training of dispatchers to ask the right questions, manage the emotional state of the caller, and give clear instructions provide callers with step-by-step instructions on how to perform CPR (4). In Singapore, a comprehensive programme of dispatcher-assisted CPR doubled bystander CPR rates and increased survival after OHCA (6).

One of the main barriers to timely initiation of EMS response and initiation of CPR is difficulty the general public has in recognising OHCA, and similarly challenges for dispatchers to diagnose OHCA over the telephone (4). This problem has been tried to be solved with initiation of dispatcher-assisted CPR instructions if the response to two initial questions is no: "is the person conscious?" and "is the person breathing normally?" (7).

Installation of public-access automated external defibrillators (AEDs) increased public access to defibrillation, but the main problem is how to link willing responders to public-access AEDs. Community training programmes that integrate public training on CPR is needed to improve survival from OHCA (4).

## CPR quality

In the 2015 guidelines update for CPR and Emergency Cardiovascular Care, the American Heart Association (AHA) reaffirmed the two cornerstones of early cardiac arrest resuscitation as: 1) quality chest compressions, and 2) early defibrillation for shockable cardiac rhythms (8, 9). Recommended chest compression rate between 100 and 120 compressions per minute at a depth of at least 5 cm (10,11). Chest compression fraction (proportion of time compressions are performed during cardiac arrest) is a critical and depends on of high-quality CPR. The AHA's stated goal for a chest compression fraction at least 60%. Specific interventions that have been proven (or proposed) to decrease chest compression fraction include vascular access attempts, advanced airway placement, and administration of intra-arrest medications. Despite the fact, that the benefits of these interventions are debatable there are alternative choices in each of these circumstances:

- Intraosseous access (IO) is as effective as peripheral or central intravenous access (IV) in patients with cardiac arrest. IO can often be secured quicker than IV, and a lower extremity IO site does not interfere with effective chest compressions.
- Supraglottic blind insertion airway devices (BIAD) are often quicker to insert than endotracheal tubes. BIADs provide effective oxygenation and ventilation, are easily inserted without interrupting chest compressions, and are proven to have a lower complication rate than endotracheal intubation (EI) (3).

**Peri-shock pause**

The duration of the peri-shock pause surrounding defibrillation is directly correlated to outcomes. Independent from chest compression fraction, peri-shock pauses in compressions of >20 s are associated with significantly decreased survival. One tactic to minimize the peri-shock pause is to begin charging the defibrillator during on-going compressions. This tactic assures that the defibrillator is ready to immediately deliver a shock before performing the pulse check between compression cycles. Pulse check and rhythm analysis can be simultaneously performed then, and shock delivered without delay. Chest compressions can be resumed immediately, with a goal peri-shock pause of <10 s (12).

**Termination of the resuscitation in the pre-hospital setting**

It is estimated that 275 000 people in Europe have all-rhythm cardiac arrest treated by EMS per year, with only 29 000 of those surviving to hospital discharge (13). Moreover, transportation with on-going CPR has recognised risks for both patients and Emergency Medical Services Personnel (EMSP). Interruptions of CPR are associated with worse survival and it is impossible to provide high quality manual CPR during the extrication of patients on a stretcher, both down stairs and through confined corridors. Such extrication and transportation to hospital may diminish resuscitation success and suggest that it is better remaining on scene than transporting to the centre (14).

Termination of resuscitation (TOR) guidelines for OHCA have been derived to identify high risk patients in whom continuing resuscitation has little chance of success. It states that resuscitation can be discontinued in the field by pre-hospital providers if the patient matches the following three criteria: the cardiac arrest was not witnessed by EMS providers; the patient did not show return of spontaneous circulation despite attempted resuscitation; and no shocks were delivered at any time before transport. Moreover, universal guideline for advanced life support (ALS-TOR) has been developed and it adds two criteria to the basic life support rule: arrest not witnessed by bystander; and no bystander-administered CPR(4).

A retrospective cohort study of adult patients who were transported to hospital with on-going CPR was conducted at three hospitals in the West Midlands, UK between September 2016 and November 2017. 227 patients were identified and 89 (39.2%) met the universal pre-hospital termination of resuscitation criteria. 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 pre-hospital termination of resuscitation. If the universal pre-hospital termination of resuscitation rule would have been applied, for patients without obvious reversible causes of cardiac arrest, resuscitation would have been discontinued at the scene for 39.2% of patients who did not survive (14).

To assess the potential consequences of implementation of the ALS-TOR rule in clinical practice, a retrospective study was performed. Cohort of non-traumatic patients with OHCA who were resuscitated by the emergency medical services (EMS) in the Nijmegen area (The Netherlands) between April 2008 and January 2011 were investigated. Of the 598 cases reviewed, resuscitative efforts were terminated in the field in 46% and 15% survived to discharge. The ALS-TOR rule would have recommended in-field termination in only 6% of patients, due to high percentages of witnessed arrests (73%) and bystander CPR (54%). In current practice, absence of ROSC was the most important determinant of termination. While designed to optimise hospital transportations, application of the ALS-TOR rule would have almost doubled hospital transportation rate to over 90% of OHCA-cases due to the favourable arrest circumstances in this region. Prior to implementation of the ALS-TOR rule, local evaluation of the potential consequences for the efficiency of triage is recommended and initiatives to improve evidence based guidance for in field triage are eagerly awaited (15).

**The Do-not-resuscitate orders**

The "Do-Not-Resuscitate" orders (DNR) are originally designed for patients whose prognosis is poor, especially for those subjects who are bearing irreversible diseases and their lives are coming to the end. Aggressive therapeutic effort will be limited when death is foreseeable and therapeutic tenacity must be avoided after DNR decisions were made by patients or their surrogates. Despite that, it is proposed that signing Do-Not-Resuscitate orders is an important element contributing to a worse prognosis for out-of-hospital cardiac arrest. A retrospective, observational analysis was performed on an adult non-traumatic OHCA who were enrolled in the Resuscitation Outcomes Consortium (ROC) PRIMED study but signed Do-Not-Resuscitate orders in hospital after admission. Patients surviving and not surviving to hospital discharge, as well as those who did and did not obtain favourable neurological recovery, were compared. Of 2289 admitted patients with DNR order signed in hospital, 132(5.8%) survived to hospital discharge and 28(1.2%) achieved moderate neurological recovery. Witnessed arrest, pre-hospital shock delivered, return of spontaneous circulation obtained in the field, cardiovascular interventions or procedures applied, and no pre-hospital adrenaline administered, were independently associated with better outcomes. This study suggest that some factors contributing to better outcomes should be taken into considerations before Do-Not-Resuscitate decisions are made in hospital for those admitted OHCA patients (16).

**Improving survival rates after In-hospital cardiac arrest**

Although survival among patients transported to hospital after pre-hospital cardiac arrest and with on-going CPR is very poor, rates of survival to hospital discharge after in-hospital cardiac arrest (IHCA) have improved over the last decade. Still it is unknown if these survival gains are sustained after hospital discharge. A study, using data from a large, national, contemporary registry linked with Medicare claims files, evaluated temporal trends of 30-dayand 1-year survival among Medicare beneficiaries with IHCA. Among 45,567 patients with IHCA, the unadjusted 1-year survival was 9.4%. Unadjusted 1-year survival was 21.8% among the 9,223 (20.2%) of patients with Ventricular Fibrillation or Pulseless Ventricular Tachycardia (VF/VT) and 6.2% among the 36,344 (79.8%) of patients with Pulseless Electrical Activity or asystole (PEA/asystole). After adjustment for patient and arrest characteristics, 1-year survival increased over time for all IHCA from 8.9% in 2000–2001 to 15.2% in 2011. Among Medicare beneficiaries in the GWTG-Resuscitation registry, 1-year survival after IHCA has increased for over the past decade. Temporal improvements in survival were noted for both shockable and non-shockable arrest rhythms. These improvements may be driven by increases in other aspects of resuscitation care, such as the quality of CPR or increased access to medications (17).

**Examples of successful resuscitation models**

Team-focused CPR (TFCPR) is one such cardiac arrest protocol used by pre-hospital providers in North Carolina. Team-focused CPR (TFCPR), also known as high-performance CPR, used by pre-hospital clinicians to streamline cardiac arrest resuscitation. TFCPR is well coordinated approach to CPR where pre-hospital responders know and practice their specific, individualized role in cardiac arrest resuscitation to optimize CPR performance, quality, and outcomes. Each clinician has predetermined role, and resuscitation is performed in a standardized and systemic algorithms. CPR is performed in sequential cycles of 200 compressions each. The clinician performing compressions counts aloud each twentieth compression (i.e., 20-40-60-80, etc.). Ventilated breaths are administered in conjunction with each twentieth compression to avoid hyperventilation and gastric over inflation, and the defibrillator is charged when the compressor announces the 180th compression. In TFCPR, the use of bag-valve-mask ventilation or blind insertion airway device is encouraged over EI. If IV is not immediately successful, then no additional attempts are made with CPR in progress and instead, an IO line is placed without delay to ensure that vascular access attempts do not interfere with effective compressions or defibrillation. Retrospective cohort analysis of 14,129 patients with OHCA in North Carolina from 2010–2014 demonstrated TFCPR benefits againts CPR. For all patients suffering OHCA survival with good neurologic outcome was significantly higher in TFCPR group, compared to standard CPR group (8.3% vs. 4.8%, $p < 0.001$). TFCPR is an established cardiac arrest resuscitation protocol that has proven effective in the pre-hospital setting, because when everyone knows their role ahead of time, intra-arrest chaos is minimized and pre-hospital survival outcomes may increase (3).

Another example of well organised successful resuscitation algorithm is damage control resuscitation (DCR) widely used in trauma patients. DCR describes a systematic approach to minimize haemorrhage, prevent coagulopathy and maximize tissue oxygenation, in order to optimize patient outcome in the major trauma patient. The concept of DCR was initially used in the military to describe an approach to managing severely injured trauma patients and now has increasingly been adopted in the civilian environment. Damage control surgery (DCS) describes the specific, systematic surgical approaches focusing on normalizing physiology from the dual insults of injury and surgery, as opposed to providing immediate definitive repair. Damage control radiology (DCRad) incorporates diagnostic and interventional radiological solutions used to treat severely injured patients. The key tenets of DCR are controlling the bleeding (including DCS and DCRad), hypotensive or novel hybrid resuscitation, haemostatic resuscitation and massive transfusion. Effective DCR starts at the point of injury. Hospital trauma team typically consists of the following core members:

- trauma team leader (TTL)
- trauma resuscitationist (anaesthetics/Intensive care) with advanced airway, vascular access, resuscitation (and increasingly procedural) skills
- airway assistant (operating department practitioner or equivalent)
- primary survey doctor (emergency medicine/general surgery)
- procedures doctor (general surgery/trauma and orthopaedic)
- procedures nurse (emergency medicine nurse)
- scribe
- runner.

As DCR evolves, much data demonstrates improved outcomes. Specific benefits include improved mortality, improved tissue perfusion, reduced acidosis, lower risk of re-bleeding and reduced volumes of both crystalloid and blood products. Considerable improvements in patient outcomes have been demonstrated with the introduction of concepts such as DCR (18).

**Framework to improve resuscitation outcomes**

Resuscitation science is improving within clinical guidelines through evidence-based process involving international experts. A multidisciplinary group of key stakeholders convened at the Utstein Abbey in Norway 1990 to develop and define standart data elements that could provide the framework for resuscitation research and quality improvement (4). The Utstein data elements are the foundation for clinical research. Several core elements have consistently been associated with survival to hospital discharge: witnessed arrest (by a bystander or EMS); bystander CPR; shorter EMS response interval; first shock-able rhythm; and return of spontaneous circulation

(ROSC) in the field. The purpose of the revised Utstein template is to provide a framework that combines the core elements of resuscitation performance for OHCA, including the community response, EMS treatments, and hospital systems of care. The goal in 2014 is to make the template intuitive to complete and effective in mapping the patient's journey through the local resuscitation system, as well as to enable knowledge sharing between resuscitation network. New or modified elements reflect consensus on then need to account for EMS system factors, increasing availability of AEDs, variability in the data collection process, trends in epidemiology, increasing use of dispatcher-assisted CPR, emerging field treatments, post resuscitation care, prognostication tools, and trends in organ recovery and transplantation (20). Survival from cardiac arrest is related inversely to the interval from collapse to definitive care. This revised Utstein template limited the core time point/interval elements to response time and time to first defibrillation, but inaccurate time-interval data from hospital resuscitation records represent a serious impediment to resuscitation research and quality improvement, weakening the conclusions of this study and many others (21). The recommendation remains that one clock (or synchronization to a single clock) be used to determine all times throughout the resuscitation attempt (20).

**Conclusion**

Although more and more studies are performed in the pre-hospital management of cardiac arrest survival rates from the OHCA remains low. Early recognition of cardiac arrest, bystander CPR and AED, public education and defibrillation training, shortening of peri-shock pause - may extremely increase survival after out-of-hospital cardiac arrest. Use of universal termination of resuscitation guidelines may decrease the number of futile emergency EMS transports without worsening survival, but more studies are needed, taking into account regional differences in arrest circumstances, before implementing it globally.

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