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Prehospital Care for Cardiac Arrest

How to Improve Outcome!

More patient lives have been saved after OHCA in recent years, but the numbers can improve further. Increased awareness, more education of laypersons and more first responders, in combination with reduced response times for the EMS and early defibrillation will save many lives.

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The chances of surviving an out-of-hospital cardiac arrest (OHCA) and returning to a good life have increased in recent years, but the numbers are still disturbingly low, with large registry studies reporting survival rates around 10% (Chan et al. 2014; Strömsöe et al. 2015). Some regions, however, have survival rates of 20% or more and could serve as role models for improved care of OHCA patients (Lindner et al. 2011).

The increased survival rates after OHCA in recent years are a result of improved prehospital as well as hospital care. This review will focus on the prehospital setting and what we can do to improve care further. The vast majority of OHCA patients have a cardiac or a presumed cardiac cause of arrest and this review will mainly address these cases. Patients with a clear non-cardiac cause of arrest, such as trauma, accidental hypothermia, suffocation, hanging and drowning have grim prognoses and will not be addressed here.

The increased numbers of patients admitted to hospital alive after OHCA are believed to be an effect of more bystanders performing cardiopulmonary resuscitation (CPR) (Hasselqvist-Ax et al. 2015), thereby shortening the critical *no-flow time*, and by improved quality of CPR (*low-flow*) by the emergency medical services (EMS), including depth and frequency of chest compressions. Improvements in survival after OHCA have been most pronounced among patients with an initial shockable rhythm. Recent data from the Swedish Register of Cardiopulmonary Resuscitation show that one in three patients will eventually have a good outcome if the initial rhythm is shockable as compared to one in twenty-five if the initial rhythm is non-shockable (Strömsöe et al. 2015). A similar development is seen in Denmark (Wissenberg et al. 2013).

First Responders

What can be done to improve prehospital care further? As noted, an analysis of what measures have been taken in those regions with the highest survival rates could serve as a good role model for many. Increased education of laypersons in CPR, including programmes for school children at all levels, will increase the rate of bystander CPR in our society and improve survival rates.

Other measures that decrease no-flow times and improve low-flow will improve survival as well. In addition to more bystander-CPR, the involvement of first responders can markedly reduce no-flow times and time to first defibrillation (Nordberg et al. 2014). Established models for first responders include involvement of fire brigades and police units, and this can be expanded further in many regions (Malta Hansen et al. 2015). Modern technology, including a mobile-phone positioning system, could instantly locate and dispatch lay volunteers trained in CPR to the scene of a cardiac arrest patient (Ringh et al. 2015). It remains to be shown that lives can be saved as well, but few doubt it, especially if combined with a positioning system for automated external defibrillators (AEDs) that would allow for laypersons to deliver very early shocks as well (Zijlstra et al. 2014). Even remote delivery of AEDs using drones has been shown to be feasible (Claesson et al. 2016). A limiting factor is, however, that the majority of OHCAs occur at home (≈70%) as opposed to a public place, which is a potential practical and legal obstacle (Hansen et al. 2017).

Emergency Medical Services

Despite educational and technological advances enabling more effective bystander interventions, the time for the EMS to arrive to the scene of the arrest remains a crucial part in the chain of survival after OHCA (Rajan et al. 2016). The early measures by the EMS (as for fire brigades and police) should include immediate manual CPR and rhythm analysis, followed by defibrillation in patients with a shockable initial rhythm. If there is no immediate return of spontaneous circulation (ROSC), the cardiac arrest algorithm should be rigorously followed with repeated rhythm analysis every two minutes. If ROSC is achieved, the patient should be immediately transferred to a hospital, ideally with angiography facilities. If the initial rhythm is shockable and if ROSC is not achieved, there are two options. Either CPR is continued on site, or the patient is rapidly transported to hospital with ongoing CPR. With current evidence insufficient for a clear recommendation on which approach is preferable, this decision is likely to be influenced by a number of local or regional system-specific factors. Regardless of whether or not transport is initiated, CPR should be continued for at least 40 minutes, since ROSC may occur after prolonged CPR in patients with initial shockable rhythm (Grunau et al. 2016; Reynolds et al. 2016). In patients with initial asystole or pulseless electrical activity (PEA) on the other hand, there are very few survivors after 20 min of continued CPR, and CPR could therefore be terminated on scene in most cases in the absence of ROSC (Grunau et al. 2016; Reynolds et al. 2016). Patients with non-shockable rhythms, who do not recover ROSC in the field, should thus not routinely be transported to hospital. Unfortunately, the proportion of OHCA patients with an initial shockable rhythm at the EMS arrival is decreasing and may be as low as one in four (25%) (Strömsöe et al. 2015).

Termination of Resuscitation Rules

The original termination of resuscitation (TOR) guidelines were proposed in 2002 (Verbeek et al. 2002) and are now referred to as the *universal* TOR guidelines, validated in 2009 and onwards for OHCA of cardiac or unknown origin (Morrison et al. 2009; Grunau et al. 2017).

In short, the universal TOR guidelines recommend termination when there has been no ROSC at any time, no shocks have been administered and the arrest was not witnessed by EMS personnel. Patients with a shockable rhythm at any time during CPR and those who arrest with the EMS present, on the other hand, fulfil the universal TOR guideline for transport and should be brought to hospital, independently of whether field ROSC is achieved or not (Morrison et al. 2009). Transport should probably be initiated without unnecessary delay in most cases. In a recent analysis of a large multicentre database, Drennan and co-workers retrospectively evaluated the universal TOR guidelines in patients transported to hospital without having achieved ROSC in the field (Drennan et al. 2017). They found that patients who met the universal TOR criteria for transport had a survival rate of 3%, as compared to 0.7% among those fulfilling the universal TOR criteria for termination, thus highlighting the importance of a TOR rule more refined than solely a lack of field ROSC.

The 2015 European Resuscitation Council (ERC) guidelines recommend using the universal TOR rules for OHCA of cardiac or unknown origin (Soar et al. 2015), and so do the authors of this paper.

Automated Chest Compression Devices

Although automated chest compression devices like the Lund University Cardiac Assist System (LUCAS®) or the Autopulse® could not be shown to improve outcomes in randomised trials (Perkins et al. 2015; Rubertsson et al. 2014; Wik et al. 2014), their use is becoming increasingly popular. Current ERC guidelines (Soar et al. 2015) do not recommend their routine use, but conclude that automated chest compressions are a reasonable alternative in certain situations, for example in the cardiac catheterisation laboratory (Wagner et al. 2010) or during transport (Gässler et al. 2013). Drawbacks with automated chest compression devices include increased costs and a possible risk for delayed defibrillation (Hardig et al. 2017; Schmidbauer et al. 2017). Also, rib fractures have been shown to increase (Smekal et al. 2014), and other injuries like sternum fractures and injuries to soft tissues seem to be more prevalent (Englund et al. 2008; Truhlar et al. 2010).

Extracorporeal Cardiopulmonary Resuscitation (eCPR)

The exciting novel field of eCPR for OHCA deserves mentioning but should be viewed as exploratory. A major obstacle is to identify the limited number of patients that may benefit from this costly, invasive and labour intensive intervention (Xie et al. 2015). There are presently seven registered trials to be found on **ClinicalTrials.gov**, of which one is completed, two are recruiting patients and two are not yet recruiting. For the remaining, the status is unknown. This highlights the increasing interest for eCPR after OHCA, and confirms the urgent need for randomised studies and studies from large eCPR registries (Soar et al. 2015).

Formula for Improved Survival after OHCA

Time to initiation of CPR and to first defibrillation after OHCA are the critical factors for outcome and all efforts should be taken to shorten them. A strategy for educating more laypeople about preventive measures and how to perform high-quality CPR will save lives, as will deployment of public defibrillators and increased numbers of first responders. Police and fire brigades are obvious first responders in many regions, and in addition, trained volunteers can be dispatched using app-based positioning systems.

> **All efforts should be made to give immediate and optimal care to all OHCA patients**

While we encourage the use of large registries to compare OHCA care and survival rates between regions, one must also bear in mind that higher relative survival rates do not automatically equal more saved lives. It is thus reasonable to also compare and present numbers of saved lives after OHCA per 100,000 population between regions in addition to percentages (Strömsöe et al. 2015).

All efforts should be made to give immediate and optimal care to all OHCA patients, with the most resources concentrated to those patients with the best chances of a good outcome. Such a strategy would probably include early transport of all patients with an initial shockable rhythm to hospital, regardless of whether field ROSC is achieved. Many patients with refractory VT/VF should be brought immediately to the cardiac catheterisation laboratory without delay and with ongoing high-quality CPR when needed. It must again be stressed that the use of automated chest compression devices and early transport directives must not delay initial (manual) CPR, initial rhythm analysis and delivery of immediate shocks when feasible.

Our common goal should be survival rates after OHCA with good functional outcome at a level of the best performers or around 20%, which would mean a doubling of saved lives from today's levels. ■

Conflict of Interest

Simon Schmidbauer declares that he has no conflict of interest. Hans Friberg declares that he has no conflict of interest.

Abbreviations

AED automated external defibrillator
CPR cardiopulmonary resuscitation
eCPR extracorporeal cardiopulmonary resuscitation
EMS emergency medical services
ERC European Resuscitation Council
OHCA out-of-hospital cardiac arrest
PEA pulseless electrical activity
ROSC return of spontaneous circulation
TOR termination of resuscitation
VT/VF ventricular tachycardia/ventricular fibrillation

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