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Review

# Prolonged CPR

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ABSTRACT

Prolonged conventional cardiopulmonary resuscitation is still associated with low success rates and high variability in survival outcome. In order to avoid continuation of what might be futile life support we will outline in this article how to identify possible candidates for prolonged CPR taking into account outcome and prognostic parameters, origin of cardiac arrest and changing therapeutic strategies. We will focus on how high quality CPR can be delivered, discuss the value of several mechanical devices and techniques that have been developed to improve outcome of CPR and propose on how possible reversible causes of cardiac arrest can be recognised and treated early. Finally we will discuss the potential benefit of extracorporeal cardiopulmonary resuscitation.



**Contents**



## 1. Background

Over the past decades, survival rates after cardiac arrest (CA) remain poor despite important improvements in cardiopulmonary resuscitation (CPR). Only 17% of all in-hospital cardiac arrest (IHCA) patients survive with good neurological outcome [1,2]. Prolonged resuscitation efforts in patients with out-of-hospital cardiac arrest (OHCA) are even associated with survival rates of less than 3% [3].

The causes of high mortality in OHCA are failure to establish a return of spontaneous circulation (ROSC) and multiple organ failure, including hypoxic brain injury in patients receiving

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conventional cardiopulmonary resuscitation (CCPR) [4]. Across the different studies focusing on early prognostic factors, a common finding is that frequency and intensity of post CA complications, and hereby the rate of favorable neurological outcome depends mainly on the quality and prolongation of CPR.

Until today the ideal or maximal duration of cardiac resuscitation is unknown. Some studies suggest that conventional resuscitation is most effective within the first 10–15 min (with a 75% rate of neurologic recovery when ROSC is achieved) and that the probability of favorable neurologic recovery fell to 2% beyond this point [5]. Recently, the group of Takahashi found that favorable outcome following ventricular fibrillation is less likely in cases of prolonged prehospital CPR (>30 min) [6]. However, a consensus statement never has been made and traditionally CPR efforts are usually terminated between 15 and 30 min [7].

Nevertheless more and more isolated case reports of successful prolonged CPR survivors are published implying that CPR duration should be established on a case-by-case basis [8–11].

## 2. What do current guidelines advice?

The ERC (European Resuscitation Council) and AHA (American Heart Association) publish guidelines for resuscitation providing specific instructions for how resuscitation should be practiced [12,13]. Until today, these guidelines do not contain a specific part about prolonged CPR, but both acknowledge continuation of CPR can be necessary as a bridge to treatment in cases with a reversible cause.

The ERC guidelines mention specifically prolonged CPR as an option in the following specific cases: bridge to dialysis in hyperkalemia, development of deep hypothermia before asphyxia, anaphylaxis and poisoning, whereas the AHA guidelines only mention continuation of CPR as bridge to PCI or in case of a hypothermic arrest.

On the other hand, both organisations provide some guidance in the decision to withhold or withdraw CPR. The ERC guidelines suggest to withdraw CPR if there is asystole for more than 20 min despite ongoing ALS, in the absence of a reversible cause. They advise to withhold CPR if there is an obvious mortal injury or irreversible death. The AHA only suggests to withdraw CPR in intubated patients, where there is a failure to achieve an $ETCO_2$ of greater than 10 mm Hg by waveform capnography after 20 min of CPR. This may be considered as one component of a multimodal approach to decide when to end resuscitative efforts, but should not be used in isolation.

However, both guidelines state clearly no single factor studied predicts outcome with sufficient accuracy to recommend termination or prolongation of CPR, although there are factors associated with better or worse outcomes.

## 3. Prognosis and outcome scales

Accurate and early prognostication of unfavorable neurological outcome in survivors of CA is of paramount importance because futile treatment of unsalvageable patients can be avoided and realistic expectations can be given. But first of all, how do we define good neurological outcome?

The Cerebral Performance Category (CPC) and Modified Rankin Scale (mRS) are both regularly used to assess functional outcomes following CA. The CPC score is the most commonly used instrument. It is a 5-category scale and was an adaptation of the GCS, which was initially developed to assess outcomes among traumatic brain injury survivors [14]. Studies have found that the CPC correlates with quality of life, prognosis, and cognitive, neurologic, and functional outcomes in post–CA survivors [15–17] (see Table 1).

The Modified Rankin Scale [18] (mRS) has been used as a measurement of global disability in stroke, brain injury, and neurosurgical patients. The mRS has some similarity to the CPC, though is more focused on functional domains, and can also be determined using chart review (seeTable 2).

The accepted definition of good neurological outcome is a CPC of 1–2 or a mRS of 0–3.

## 4. Prognostic factors during CPR

In order to identify potential candidates for prolonged CPR it is essential to integrate patient's premorbid condition as well as all circumstances of the arrest.

Older patients (>70 years) have a lower likelihood of survival to discharge [19,20]. Nursing home residency, dependent functional status, homebound lifestyle and pre-arrest comorbidity are also associated with decreased chances of survival [21]. Among comorbidities, sepsis, cancer, renal failure, myocardial infarction, congestive heart failure and diabetes are significantly associated with poor survival [22]. The majority of studies on CA do not document any effect of gender on survival. However, at least one study [23] reported that female gender was an independent predictor for survival to discharge. A strong association between race and outcome from cardiovascular disease has been reported [24]. Survival after both OHCA [25] and IHCA [26] arrest is lower in black patients.

It is also well known that the survival rate from shockable rhythms VF/VT, which is 35%, is significantly higher than the 10% survival rate for non-shockable rhythms asystole and PEA [1].

The return of spontaneous circulation after cardiac arrest (RACA) score is a simple tool for calculating the probability of ROSC in OHCA. It may also have implications as a quality indicator for the emergency medical service (EMS) system and it may help analysing the effects of different resuscitation strategies and post-resuscitation interventions in patients with a comparable RACA [27]. (see Fig. 1).

Megarbane et al. studied the usefulness of some routine laboratory findings in the decision to treat refractory cardiac arrest pointing out that the predictive value of blood lactate, venous oxygen saturation ($SpvO_2$) and coagulation disorders at arrival in the emergency department equally deserves more detailed evaluation. They recommended to not implement extra corporal life support (ECLS) when SpvO2 is $\leq$ 8%, plasma lactate concentration $\geq$21 mmol/l, fibrinogen $\leq$0.8 g/l, or prothrombin index $\leq$11% after prolonged CPR [28]. Also pupil diameter on hospital arrival may be a key predictor to identify extracorporeal cardiopulmonary resuscitation candidates [29].

Summary: Indicators to choose or not to choose for prolonged CPR.

| PRO | CON |
|---|---|
| Age 0–65 years | Pre-arrest cognitive or functional status severely impaired |
| Witnessed arrest | Multiorgan dysfunction |
| Bystander CPR | Severe sepsis |
| VF/VT as initial rhythm or obvious cardiac or other reversible etiology with PEA/asystole | Major pre-existing medical comorbidities |
| Collapse to EMS arrival <15 min | High velocity cardio/cerebral trauma |

## 5. High quality CPR

Improving survival from CA requires a series of timely interventions before and upon ROSC commonly called the links in the

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