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## Review

## Do cardiac arrest centres save more lives?

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## ABSTRACT

During the last 15 years post resuscitation care after out-of-hospital cardiac arrest (OHCA) has evolved into something quite complicated and multifaceted. Still, in most countries post resuscitation care is not centralised to specialised hospitals. In other acute and life-threatening diseases like neuro-trauma, acute myocardial infarction and stroke specialised hospital care has now become standard practise. In this review, we present the historic changes in post resuscitation care with a focus on the trends in the international resuscitation guidelines after they first mentioned specialised cardiac arrest centres as an option to improve outcomes in 2005. Studies from several countries have shown that post resuscitation care varies significantly between hospitals, and that this variation may explain a substantial part of the noted difference in survival. Although the impact of the individual ingredients is still debated, some of the services a cardiac arrest centre must offer are now well defined: 1) general intensive care, including mechanical ventilation and target temperature management (TTM), 2) acute cardiac care including coronary angiography and percutaneous coronary intervention (PCI), 3) 24-h radiology service with computed tomography (CT) availability, and 4) delayed, multi-modality and standardised neuro-prognostication. Maybe, even as important, is the hospital commitment to this group of patients. In the 2015 international resuscitation guideline update cardiac arrest centres is also highlighted as a way to improve overall outcome. However, very few countries have implemented regional resuscitation systems with integrated cardiac arrest centres. Hopefully this will change in the years to come.

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## 1. Introduction

Treatment in specialised institutions is now widely accepted for a variety of medical diseases and conditions. Admission to

specialised acute myocardial infarction (AMI), trauma and stroke centres, for instance, has been associated with a reduction in both mortality and morbidity [1–4]. For out-of-hospital cardiac arrest (OHCA) patients most focus had been directed to the first three prehospital links of the chain of survival – early recognition, early cardiopulmonary resuscitation (CPR) and early defibrillation (Fig. 1). The significance of the fourth link of early high-quality post-resuscitation care, however, has experienced slow but increasing acknowledgement by the 2000, 2005, and 2010

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Fig. 1. European Resuscitation Council (ERC) Chain of Survival (from Nolan J, Soar J, Eikeland H. The chain of survival. *Resuscitation* 2006; 71:270-1). Used with permission.

resuscitation guidelines. Interestingly, Peter Safar, a founding father of resuscitation and critical care medicine, stressed the importance of post resuscitation therapy, including cooling of the brain, as early as 1964 [5].

In 2003, Langhelle et al. [6] caused a renewed interest in the fourth link of the chain of survival (Fig. 1) when the group published their comparison of post resuscitation care in out-of-hospital cardiac arrest (OHCA) survivors in 4 Norwegian hospitals and the associated difference in survival. The concurrent publications on therapeutic hypothermia (TH) gave a new boost to the field of post resuscitation care [7,8]. Emergency percutaneous coronary interventions (PCI) in OHCA survivors with a ST-elevation acute myocardial infarction (STEMI) also appeared to affect survival [9]. Further, some leading resuscitation centres presented data showing how a standardised and more active approach to unconscious OHCA survivors produced extraordinary improvements in hospital survival [10].

In this review we will look at trends in post resuscitation hospital care during the last 10 years and try to answer the specific question; do specialised cardiac arrest centres save more lives?

## 2. International consensus on science and treatment recommendation – 2005 to 2015

The International Liaison Committee on Resuscitation (ILCOR) embraced the TH concept already in 2003 [11] and expanded their treatment recommendation in the 2005 guidelines [12] as well as in a specific position paper on the “post-resuscitation syndrome” in 2008 [13]. Still, implementation of their treatment recommendations was low, with huge variation in its use [14]. While some European centres have reported use of TH in up to 70% of unconscious OHCA survivors admitted to the ICU [15], some countries like the USA has reported a dismal 1% implementation rate [16]. In 2010, ILCOR repeated their treatment recommendations and the European Resuscitation Council (ERC), American Heart Association (AHA) and other members of ILCOR again included TH in their post resuscitation guidelines [17,18].

During this period the term TH was also replaced with a new idiom - targeted temperature management (TTM) - to better delineate the concept of temperature control to reduce brain injury [19]. In 2013, the results from a large and well-conducted international randomised controlled trial (RCT) (“the TTM trial”) comparing the previous targeted core temperature of 33 °C with a temperature closer to normal temperature (36 °C) was published [20]. The authors did not find any difference between the two TTM approaches, neither in mortality nor in other outcomes [21,22]. This has caused a heated discussion on whether to cool at all, and to

what target temperature [23,24]. Some interpreted the TTM trial as a negative trial, and not a neutral one, and stopped cooling altogether [24]. Trying to reach consensus in 2015, ILCOR still recommend post resuscitation cooling for a minimum of 24 h but extended the target temperature range from 33 °C to 36 °C [25]. There are still significant knowledge gaps in this field, one of them being the impact of length of cooling.

Both in the ILCOR 2015 update [26], as well as in other international cardiology guidelines [27], a liberal use of emergency coronary angiography (CAG) in OHCA survivors, and PCI if indicated, are still recommended. Importantly, this recommendation is not based on any RCT but extrapolation from studies in STEMI patients without OHCA, together with evidence from observational studies in OHCA survivors. Still, the majority of international experts in interventional cardiology now recommend this aggressive approach [28–30].

Proper prognostication has also been shown to be of outmost importance in OHCA patients. Premature prognostication may lead to untimely withdrawal of life support like endotracheal intubation, mechanical ventilation and hemodynamic support [31–34]. This again might lead to self-fulfilling prophecies with patients dying from airway or circulatory problems before achieving cerebral recovery. Numerous studies have shown that the use of traditional prognostic criteria results in unacceptable high false predictive values in the TTM treated OHCA population [33,34]. The 2015 guidelines [35] recommend waiting 4–5 days before final prognostication and withdrawal of life support. Scientific bodies like the ERC and the European Society of Intensive Care Medicine (ESICM) have also cooperated in composing very specific guidelines for neuro-prognostication in these patients [36]. Sadly, these guidelines is not reflected in current practice [37,38], and the multimodality prognostication tools and expertise needed (neurophysiology, neuroimaging and serum biomarkers) is hardly available in all hospitals admitting post resuscitation patients at present.

The 2015 ILCOR recommendations [39] also support regionalised care with integrated cardiac arrest centres to boost survival. Surveys of post resuscitation care, however, indicate a large gap between published guidelines and the actual care provided [38]. One key finding is the large variation in hospital care. A large proportion of hospitals admitting OHCA survivors do not have a predefined protocol. Accordingly, use of TTM, emergency PCI and standardised neuro-prognostication vary significantly. Much of the care given seems to be based on physician discretion and not protocol. The great difference in care provided, however, starts before ICU admission with ICU triage. Unreliable negative predictors of bad outcomes are widely used as criteria for not admitting patients to the ICU [38,40]. Hence, very early prognostication and

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